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Efforts and Programs of the Department of Defense Relating to the Prevention, Mitigation, and Treatment of Blast Injuries

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EXECUTIVE SUMMARY

Section 256 of the National Defense Authorization Act for Fiscal Year 2006, Public Law 109-163, provides that the Secretary of Defense shall submit a report on the efforts and programs of the Department of Defense (DoD) relating to the prevention, mitigation, and treatment of blast injuries. The report is to include the following elements of information:

1. A description of the activities undertaken under this section during the 2 years preceding the report to improve the prevention, mitigation, and treatment of blast injuries.
2. A consolidated budget presentation for DoD biomedical research efforts and studies related to blast injury for the 2 fiscal years following the year of the report.
3. A description of any gaps in the capabilities of the Department and any plans to address such gaps within biomedical research related to blast injury, blast injury diagnostic and treatment programs, and blast injury tracking and monitoring activities.
4. A description of collaboration, if any, with other departments and agencies of the Federal Government, and with other countries, during the 2 years preceding the report in efforts for the prevention, mitigation, and treatment of blast injuries.
5. A description of any efforts during the 2 years preceding the report to disseminate findings on the diagnosis and treatment of blast injuries through civilian and military research and medical communities.
6. A description of the status of efforts during the 2 years preceding the report to incorporate blast injury effects data into appropriate programs of the DoD and into the development of comprehensive force protection systems that are effective in confronting blast, ballistic, and fire threats.

As presented in this report, during the previous 2 years the DoD has undertaken more than 160 activities necessary to improve the prevention, mitigation, and treatment of blast injuries. A consolidated budget has been developed for DoD biomedical research efforts and studies related to blast injury for fiscal years 2007, 2008, and 2009. Gaps in the capabilities of the Department have been identified thereby enabling the Department to align and develop a portfolio of biomedical research efforts to delineate the future directions of blast injury research. Numerous collaborative efforts with other departments and agencies of the federal government and with other countries have enabled the Department to optimize scientific growth and productivity in this area, as well as resource sharing. Efforts by the Department to disseminate findings on the diagnosis and treatment of blast injuries through civilian and military research and medical communities show a widespread effort with over 480 presentations, 235 publications, and 150 technical reports critical to exponentially moving the scientific efforts of this field forward. Finally, over the previous 2 years, the Department has worked very hard to incorporate blast injury effects data into “end user” programs focused on the development and implementation of comprehensive force health protection systems.

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CHAPTER 1
INTRODUCTION

Section 256 of the National Defense Authorization Act for Fiscal Year 2006, Public Law 109-163, provides that the Secretary of Defense shall designate an executive agent to be responsible for coordinating and managing the medical research efforts and programs of the Department of Defense (DoD) relating to the prevention, mitigation, and treatment of blast injuries. The Department issued DoD Directive (DoDD) 6025.21E *"Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries"* on July 5, 2006 in compliance with Section 256 of Public Law 109-163. DoDD 6025.21E designates the Secretary of the Army as the DoD Executive Agent (DoD EA), assigns responsibilities governing coordination and management of Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries, and directs the Armed Services Biomedical Research Evaluation and Management Committee to facilitate coordination and prevent unnecessary duplication of effort within DoD biomedical research and development and associated enabling research areas.

Blast injury occurs as the result of the detonation of high explosives, including vehicle-borne and person-borne explosive devices, rocket-propelled grenades, and improvised explosive devices (IEDs). The DoD program on Medical Research for Prevention, Mitigation, and Treatment of Blast Injuries uses a taxonomy to characterize such injuries. *Primary blast injury* is the result of blast overpressure (BOP) resulting in direct tissue damage from the shock wave coupling into the body. *Secondary blast injury* is produced by primary fragments originating from the exploding device (preformed and natural [unformed] casing fragments and other projectiles deliberately introduced into the device to enhance the fragment threat) and secondary fragments, which are projectiles from the environment (debris, vehicular metal, etc.). *Tertiary blast injury* is the displacement of the body or part of the body by the BOP causing acceleration/deceleration to the body or its parts, which may subsequently strike hard objects causing typical blunt injury (translational injury), avulsion (separation) of limbs, stripping of soft tissues, skin speckling with explosive product residue and building structural collapse with crush and blunt injuries, and crush syndrome development. *Quaternary blast injury* is the result of other "explosive products" effects—heat (radiant and convective) and toxic toxidromes from fuel, metals, etc.—causing burn and inhalation injury. Last, *quinary blast injury* refers to the clinical consequences of "post detonation environmental contaminants" including bacteria (deliberate and commensal, with or without sepsis), radiation (dirty bombs), and tissue reactions to fuel and metals.

The DoD has developed medical research program management categories to plan, program, budget, and manage execution of the activities of the Department associated with the prevention, mitigation, and treatment of blast injuries. This taxonomy facilitates sustainment of programmatic focus on preventing, mitigating, and treating the common categories of injuries while allowing for an additional management focus on enabling technologies that facilitate improvements in understanding the causes and types of blast-related injury and in providing biomedically valid design criteria and test methodology for assessment of protective materiel. The program management categories are:

- **Surveillance**

  The Surveillance category informs and guides the entire program effort and provides essential, near real-time feedback on changes in the threat, increased vulnerabilities and successful interventions. The centerpiece program effort being developed is the Joint Trauma Analysis for Prevention of Injury in Combat (JTAPIC) program. It consists of a coordinated effort among the medical, intelligence, and nonmedical materiel development communities to share information for the prevention and mitigation of traumatic injuries in combat using common standards to ensure its validity and ensure the information can be used in an appropriate manner. The program will establish a joint database for collection, analysis, and sharing of information gathered by DoD Components to enable the development of improved tactics, techniques, and procedures (TTPs), materiel solutions, medical treatments, and models to mitigate and prevent combat injury. Activities include the integration of wounding and nonwounding incident operational data, injury

data and combat casualty care analysis, and protective equipment performance data and forensic equipment analysis. Surveillance activities support Combat Developers, Materiel Developers, and Acquisition Executives in their respective roles to develop organization and equipping concepts; determine materiel requirements; evaluate materiel alternatives and modifications; acquire new and improved materiel items; integrate systems, concepts, and programs; and adjust DOTMLPF (Doctrine, Organization, Training, Material, Leadership and Education, Personnel, and Facilities) and TTP to increase force effectiveness.

- **Traumatic Brain Injury**

  The Traumatic Brain Injury category focuses on the diagnosis, treatment, and rehabilitation of service members with traumatic brain injuries (TBIs), including both penetrating and blunt injuries. Examples of research products include diagnostic tools that can detect mild TBI (mTBI) and distinguish it from mental health disorders; pharmaceuticals, such as neuroprotectants; criteria for withdrawal from duty and return to duty following TBI and strategies to improve the long-term outcomes of TBI. The Defense and Veterans Brain Injury Center (DVBIC) and its network partners in the Military Health System (MHS) and Department of Veterans Affairs (VA) will serve as a primary testbed for translational research for mild to moderate TBI. The Washington Area Neurosurgical Consortium will serve a similar role for severe TBI. Spinal cord injury (SCI) is managed within the Other Tissues and Organs program category.

- **Injuries to Other Tissues and Organs**

  The category of Injuries to Other Tissues and Organs consists of activities that focus on the acute and definitive treatment of blast-induced injuries to body tissues and organs. This focus area builds upon the traditional combat casualty care and military operational medicine research efforts of the Department with new emphasis in rapid wound healing, including infection diagnosis and control, and tissue regeneration. Both blood and bone are considered tissues of focal interest in this area; research products include enhanced field treatments for blood loss from traumatic injuries. Examples of other research products include tools, such as biomarkers, to rapidly diagnose blast-induced lung and internal organ injuries and drugs to treat internal organ injuries.

- **Modeling, Simulation, Test, and Evaluation**

  The Modeling, Simulation, Test, and Evaluation category encompasses activities with a focus on understanding how blasts interact with the human body to cause injuries. Modeling and simulation research includes animal tests to establish injury patterns, elucidate injury mechanisms, and provide data for establishing injury criteria; mathematical modeling of physiological response in both animals and humans; and instrumentation to standardize the measurement of blast environments for injury assessments. Examples of modeling and simulation research products include biomedically valid blast injury prediction tools and injury criteria that can be used to drive the development of improved personal protection and vehicle occupant survivability systems.

  Activities relative to test and evaluation focus on the application of biomedically valid blast injury criteria and blast injury prediction tools to assess the effectiveness of personal protective equipment and vehicle occupant survivability systems.

- **Injuries to the Extremities**

  The Extremity category consists of efforts that focus on the rehabilitation of blast-induced injuries of body limbs. Research efforts in this category will include advancement of prosthetic technology and improvement in occupational and physical therapies. These efforts will leverage the three DoD Amputee Centers as testbeds for advances in medical care. Because of commonalities and potential synergies in scientific approach, research directed at mitigation and treatment of limb injuries will be managed as part of the Other Tissues and Organs program area portfolio. For similar reasons, research directed toward improved biomedical design guidance for nonmedical protective

equipment for limbs will be managed as part of the Modeling, Simulation, Test, and Evaluation category portfolios.

- **Face and Eye Injury**

  The Face and Eye Injury category focuses on the acute and definitive treatment of blast-induced face and eye injuries. Examples of research products include improved acute treatment methods that mitigate damage and enhance follow-on cosmetic surgery and novel strategies to repair and restore oral, dental, and craniofacial tissues, including the eye. Additionally, new approaches to mitigation and treatment of retinal injuries due to mechanical trauma will be part of this program area focus. As in the case of prevention of auditory and extremity injuries, nonmedical protective materiel advancements for face and eye injury will be enabled by work in the Modeling, Simulation, Test, and Evaluation category.

- **Auditory Injury**

  The Auditory Injury category focuses on the diagnosis and treatment of service members with blast-induced auditory injuries. The goal is identifying and obtaining U.S. Food and Drug Administration (FDA) licensure for drugs to mitigate and treat hearing loss. Prevention of auditory injuries through improved hearing protection devices will continue to be a goal of nonmedical materiel development programs supported by the medical research program. Such efforts will be facilitated by the medical research community through development of improved biomedical models of hearing loss and associated hearing protection evaluation technology. These latter efforts will be managed as part of the Modeling, Simulation, Test, and Evaluation category.

Figure 1-1 depicts the relationships between the physiologic/anatomic injury domains (i.e., TBI, Auditory, Face and Eye, Extremity, and Other Organs) of the program taxonomy to the cross-cutting enabling capabilities of surveillance, modeling and simulation, and test and evaluation. Enhanced prevention, mitigation, and treatment of blast-related injuries will be founded upon improved understanding of the threat provided by the surveillance activities of the JTAPIC and enabled by advances in biomedically valid design criteria and evaluation methodologies provided by modeling, simulation, test, and evaluation research. Although there are significant technical barriers inherent in several program areas, the program will be managed to provide improvements in all areas as they become available, including accelerated near-term solutions based on previous research efforts. The program brings to bear the coordinated efforts of the medical research and health care delivery communities, augmented by the intelligence community, in support of the materiel developers and warfighters.

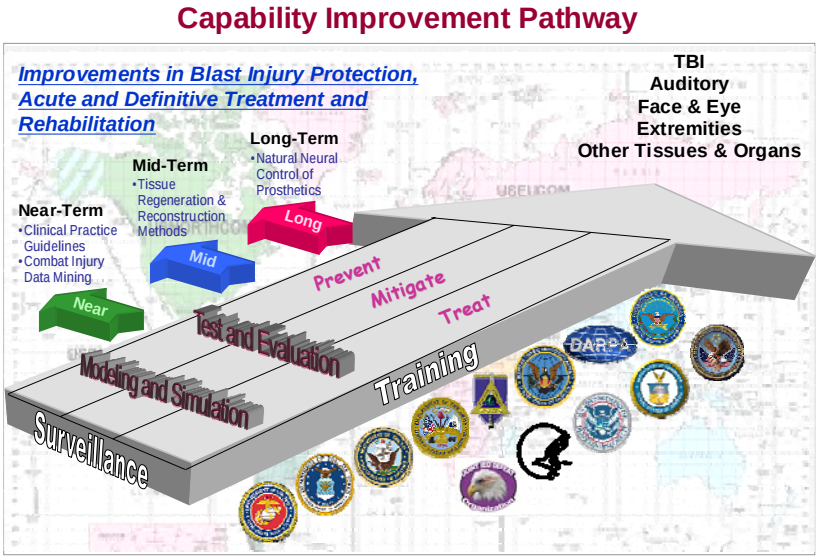

Figure 1-1. Capability Improvement Pathway

CHAPTER 2

Requirement: A description of the activities undertaken under this section (Sec 256, PL 109-163) during the 2 years preceding the report to improve the prevention, mitigation, and treatment of blast injuries.

A description of the biomedical research and technology activities undertaken during the previous 2 years to improve the prevention, mitigation, and treatment of blast injuries is presented by each functional program category. It is important to note that these activities vary in scope and complexity ranging from individual protocols or studies to more encompassing program efforts, are in various stages of maturity or progress, range from basic research to advanced development, and most continue over several years.

Surveillance

- ***Blast Injury Epidemiology:*** This study describes the epidemiological characteristics of blast injury and evaluates those factors associated with blast injury during Operation Iraqi Freedom (OIF). In addition, the affects of personal protective equipment (PPE) on blast injury are being examined. The incidence of blast injury during military operations in Iraq has increased and can overwhelm both civilian and military medical resources. *Performer:* Navy (Naval Health Research Center [NHRC])
- ***Combat Critical Care Engineering—Warfighter Physiological Status Monitor (WPSM):*** The WPSM is being developed to provide timely health monitoring, detection of ballistic-wounding events, and basic triage information remotely. *Performer:* Army (U.S. Army Medical Research and Materiel Command [USAMRMC])
- ***Extremity Injury Profiles:*** This study assesses characteristics of extremity injury among U.S. military casualties from the stability and support phase of OIF. A retrospective analysis of trauma registry data is being performed. Data are collected from the Navy–Marine Corps Combat Trauma Registry (CTR). *Performer:* Navy (NHRC)
- ***Head Neck and Face Injury Severity:*** This study assesses characteristics of head, face, and neck injury among U.S. military casualties from the stability and support phase of OIF. A retrospective analysis of trauma registry data is being performed. Data are collected from the Navy–Marine Corps CTR. *Performer:* Navy (NHRC)
- ***IED Shrapnel and Blast Characterization:*** This effort provides realistic fragment and BOP information from road-side artillery shell IEDs in current operations to determine the injury environment to the human in IED events. *Performers:* Army (U.S. Army Aeromedical Research Laboratory [USAARL]) and DoD Live Fire Test and Evaluation Program
- ***Mid-term Outcomes Following Wartime Extremity Vascular Injuries: A Report from the 59th MDW:*** This project is investigating the clinical outcomes following definitive surgical repair of wartime extremity vascular injuries. Specifically, the overall limb salvage rate, the number and type of additional surgical interventions required for limb salvage, the functionality of repaired limbs and the quality of life with either repaired limb or following delayed amputation. This approach will reinforce current practice or significantly modify the management of wartime extremity vascular injuries. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Next Generation Body Armor (NGBA):*** The NGBA program was initiated by the Technical Support Working Group (TSWG) in FY06 to prototype the capability of applying epidemiological data to design decisions for NGBA. Under this effort, TSWG's contractor successfully merged three key epidemiological databases from ongoing operations in Iraq and Afghanistan. Using the data from these three databases, the contractor demonstrated the feasibility of linking the epidemiological data with tactical forensics data and demonstrated the

application of the surface wound mapping (SWM) technology as a tool for interrogating the injury data. Also during FY06, TSWG began developing a network of trained end-users of SWM technology and wound-mapped trauma data. *Performers:* DoD (TSWG) and SimQuest, LLC.

- ***Small Unmanned Ground Vehicle (SUGV)-integrated Non-contact Deep Ultraviolet (UV) Biochemical Agent Surface Detector (UVBASD):*** This Phase 1 Small Business Innovation Research (SBIR) addresses the need for miniature, low-power, reagent-less, robot-mounted instruments for real-time detection and classification of trace concentrations of biological and chemical agents on surfaces. Photon System proposed an advanced, robot-mounted, electro-optical instrument that combines UV laser-induced native fluorescence and UV resonance Raman spectroscopy for noncontact detection and classification of trace concentrations of biological and chemical agents while requiring no consumables or sample preparation and producing no waste products. *Performers:* Army (USAMRMC) and Photon System
- ***Wartime Critical Care Air Transport:*** This effort describes the type and frequency of casualties transported by the U.S. Air Force (Air Force) Critical Care Air Transport Teams in support of Operation Enduring Freedom (OEF)/OIF and the care provided enroute, complications that occurred during transport, and patient outcomes. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Wartime Critical Care Air Transport: Ground Transport (CCATT) Problems:*** This effort identifies the problems experienced during the ground transport of CCATT patients and relates factors that may be associated with the problems incurred. It is important to identify the problems to facilitate informed decisions related to care guidelines, education/training, and system processes for the movement of critically ill/injured patients. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Wound Surface Mapping:*** This endeavor expands the volume and scope of data collected and the functionality of analytical tools provided to the personal protective devices design community. Specifically, it ramps up populating SWM databases, with a goal of 3,000 cases entered. Follow-on studies include the ability to analyze wounding patterns relative to body armor by adding morphology data capability to SWM. This permits the extrapolation of wound/injury data to warfighters of different sizes. *Performers:* SimQuest LLC, Army (USAMRMC, Joint Theater Trauma Registry), DoD (Armed Forces Medical Examiner), and U.S. Marine Corps Systems Command

Traumatic Brain Injury

- ***A Randomized Placebo-controlled Trial of Citalopram for Anxiety Disorders Following TBI:*** This effort studies the effects of citalopram, a serotonin reuptake inhibitor, for the treatment of anxiety experienced by individuals after TBI. This project seeks to treat individuals who meet criteria for DSM-IV diagnosis of Anxiety Disorder Due to a General Medical Condition TBI within 6 to 14 months of injury. *Performer:* DoD (DVBIC) and Air Force (59th Medical Wing Wilford Hall)
- ***A Randomized Placebo-controlled Trial of Sertraline for the Neurobehavioral Sequelae of TBI at DVBIC Military Sites:*** This study examines the effectiveness of Sertraline in treating post-TBI neurobehavioral systems of irritability, depression, frustration, anxiety, and other elements of the post-concussive syndrome. Patients with blast-related TBIs are compared to patients with other TBIs to determine relative treatment effectiveness in these two populations. *Performer:* DoD (DVBIC)
- ***Applied Research in Neuroprotection:*** This effort developed a new experimental model of penetrating ballistic-like brain injury and completed the histopathological characterization and neurofunctional assessment of the model out to 7 days post-injury. This effort also consists of comprehensive preclinical studies demonstrating dose- and time-dependent neuroprotective

effects of a novel therapeutic, NNZ2566. *Performers:* Army (USAMRMC) and Neuren Pharmaceuticals

- ***Blood-based Therapy for Traumatic Brain Injury:*** Banyan Biomarkers will use the biomarker analytical tools generated in the past 3 years to guide development of new molecular entities (NMEs) that have potential as a drug treatment for TBI. The NMEs will be designed to target both calpain and caspase, and therefore to enhance inhibition of the destructive cascade and therapeutic potential. Because the biomarker analytical tools can indicate brain injury and calpain and caspase activation, they can be used to guide development of specific inhibitors to both these proteases. The overall goal of this work is to identify a lead compound that can be taken forward into preclinical development as a treatment for TBI in humans. *Performers:* Army (USAMRMC) and Banyan Biomarkers
- ***Chronic Epilepsy in Severe Head Injuries:*** This program provides support for investigator-initiated research of relevance to the prevention and treatment of post-traumatic epilepsy, including the cellular, molecular, and systems-level understanding of the underlying pathogenic mechanisms; specific approaches to interdict the development of post-traumatic epilepsy; animal models of post-traumatic epilepsy; and investigations of the impact, natural history, and epidemiology of post-traumatic epilepsy. *Performers:* Army (USAMRMC) and Industry
- ***Community Re-entry for Blast-injured Fighters at Virginia NeuroCare and Laurel Highlands Rehabilitation Center:*** This program provides active-duty blast patients with community re-entry, transitional living, and vocational and outpatient neuro-rehabilitation services. *Performer:* DoD (DVBIC)
- ***Comprehensive National Neuroscience Program (CNNP):*** This is a multisite, collaborative clinical research program addressing neurological disorders affecting the military population in an attempt to preserve the health of service members and their dependents. The program focuses on three core areas: acute neurology, headache, and neuromuscular disorders. Area 1: The acute neurology program focuses on acute, severe, life-threatening neurological or neurosurgical illnesses and injuries, particularly TBI. Area 2: Headache disorders are common and are among the leading medical causes of missed workdays and lost productivity. Area 3: Neuromuscular disorders such as exertional rhabdomyolysis, amyotrophic lateral sclerosis, and peripheral nerve injuries are major concerns for military members in both training and operational environments. *Performers:* Army (USAMRMC) and Industry
- ***Defense and Veterans Brain Injury Center (DVBIC) Core Evaluation Protocol:*** This multidisciplinary evaluation battery provides detailed, standardized assessments of patients with TBI treated in the seven lead DVBIC centers. The assessments are initiated and used by clinicians to provide information to plan treatments for patients. Approximately 250 soldiers injured in OIF/OEF and evacuated for care at the Walter Reed Army Medical Center (WRAMC) have received core protocol evaluations under this treatment protocol. The results provide initial evidence on the effects of blast-related versus nonblast-related TBIs. *Performer:* DoD (DVBIC)
- ***Defense and Veterans Head Injury Program: Effects of Gradual Return to Work Following Mild Closed Head Injuries:*** This effort compares two different approaches to returning to work after an mTBI. One approach involves 2 weeks' convalescent leave followed by 1 week of limited duty. The second approach is 3 weeks of limited duty. Both approaches are under a physician's orders to avoid activities that are mentally, emotionally, or physically demanding. *Performers:* Air Force (59th Medical Wing Wilford Hall) and DoD (DVBIC)
- ***DVBIC Prospective and Retrospective TBI Clinical Tracking Protocol:*** The purpose of this study is to ensure that all military (DoD) and VA TBI patients receive TBI-specific evaluation and follow-up by creating a database of clinical data obtained during standard TBI evaluation. These data are analyzed in a descriptive, observational study and describe the clinical characteristics of

TBIs occurring in theater, as well as the correlative etiology of the TBI with demographics, injury severity, associated injuries, symptomatology, and outcomes (e.g., return to duty and work). The TBI patient population has grown exponentially and becomes more complex in recent years because of the serious and multi-system trauma received in current conflicts. This study collects information about symptoms and recovery after TBI that will allow comparison of the effectiveness and cost of various TBI treatment and rehabilitation strategies and help determine what is the best care for individuals who have experienced a TBI. *Performer:* DoD (DVBIC) and Henry M. Jackson Foundation (HMJF)

- ***DVBIC Randomized Controlled Trial (RCT)—The Effectiveness of Methylphenidate:*** This program is: (1) determining Class 1 evidence on the effectiveness of methylphenidate during acute rehabilitation in improving outcome after moderate to severe TBI; (2) completing follow-up evaluation, analyzing data, and generating findings for the current DVBIC RCT that investigates the efficacy of a didactic cognitive treatment program versus a neuro-functional treatment program; and (3) conducting single-center pilot studies that test innovative approaches for the assessment and treatment of TBI patients. *Performer:* DoD (DVBIC)
- ***Enhanced Neurorehabilitation for TBI:*** This effort develops TBI rehabilitation for OIF veterans using non-pharmaceutical alterations in environment. *Performers:* Air Force (HQ USAF/Surgeon General), DoD (DVBIC), Wright State University, University of Ottowa and Carlton University, Canada
- ***Measurement of Executive Dysfunction in Concussive Brain Injury Patients:*** This effort compares patients with concussive brain injury enrolled in the DVBIC at WHMC to age-matched controls and patients with other types of injuries not affecting the brain (e.g., gunshot wounds to the extremity) and also normal controls. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Mental Illness Research, Education, and Clinical Center (MIRECC) Neurocognitive Protocol for Blast and Nonblast Patients:*** This study investigates post-deployment post-traumatic stress disorder (PTSD) and TBI in recently discharged veterans, active-duty military and returning National Guard personnel to discriminate between the two separate disorders and specify their degree of co-morbid occurrence. It also examines the longitudinal course and outcome, with a particular interest in the effect of change in one disorder on the presentation of the other and in isolating variables that predict therapeutic improvement. *Performer:* DoD (DVBIC)
- ***Mental Illness Research, Education and Clinical Center (MIRECC) Recruitment Protocol for Blast and Nonblast Patients:*** This study is recruiting and characterizing subjects for a database from which to draw subjects for future studies to look at three principal aims: (1) to determine whether early intervention in post-deployment mental health is effective in forestalling the development or decreasing the severity of post-deployment mental illness, (2) to determine what neuroimaging, neurocognitive, or other characteristics predict the development of post-deployment mental illness, and (3) to assess the longitudinal course of post-deployment mental illness. *Performer:* DoD (DVBIC)
- ***Military Blast-related Traumatic Brain Injury—A Study of Neuroanatomical and Neurobehavioral Sequelae and Low-cost Clinical Intervention:*** This study is: (1) developing prevalence estimates for sequelae (neuroanatomical and neurobehavioral) of blast-related TBI in a military population; and (2) testing the efficacy of a low-cost telephonic clinical intervention. Comparisons are made between blast/nonblast-related TBIs and treated/nontreated groups. *Performer:* DoD (DVBIC)
- ***MRI-DTI Tractography to Quantify Brain Connectivity in Traumatic Brain Injury:*** This project is developing new data processing strategies and technology for MRI (magnetic resonance imaging) diffusion tensor imaging (DTI)-based tractography to address damage caused by diffuse axonal injury (DAI) and predict patient outcome. The key problem to be addressed is the

development of an appropriate methodology to quantify axonal connectivity following brain injury and its validation through correlation with clinical and neuropsychological test scores. *Performers:* Army (USAMRMC) and Industry

- ***Noninvasive Monitoring of Intracranial Pressure:*** This research consists of several technology applications that will lead to noninvasive devices for monitoring intracranial pressure (ICP) in far-field use. *Performers:* Army (USAMRMC), Infoscitex, and other Industrial Partners.
- ***Pilot Study: Incidence and Characteristics of Post-traumatic Stress Disorder Following Traumatic Brain Injury:*** This effort focuses on TBI within a combat environment on the theory that combat presents some unique stressors not encountered in other situations. This is a two-part study, the first being a retrospective analysis of the incidence and severity of PTSD symptoms in a large sample of DVBIC TBI patients. The second part is a prospective analysis of PTSD in returning military service members who received a TBI while deployed to OIF or OEF. *Performers:* Air Force (59th Medical Wing Wilford Hall) and DoD (DVBIC)
- ***Post-traumatic Stress Syndrome: The Combat Trauma Registry (CTR) at Naval Health Research Center (NHRC):*** This proposal: (1) describes and compares the rates of PTSD and other mental health outcomes among injured OIF combatants and examines the association of combat versus noncombat injury; (2) identifies injury-related predictors of PTSD—to include vital signs (heart rate, blood pressure), injury severity, injury mechanism, and injury location—among injured OIF combatants; and (3) examines the risk of PTSD and other mental health outcomes among injured OIF combatants with TBI. *Performer:* Navy (NHRC)
- ***Post-traumatic Stress Disorder Symptom Severity among Airmen Deployed to Iraq:*** This effort determines the possible extent of PTSD among USAF members departing Kirkuk AB, Iraq in August–October 2004. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Recruitment Protocol for Blast and Nonblast Patients:*** This study's primary goal is research of post-deployment mental illness. The study is recruiting and characterizing subjects for a database from which to draw subjects for future studies to look at three principal aims: (1) to determine whether early intervention in post-deployment mental health is effective in forestalling the development or decreasing the severity of post-deployment mental illness, (2) to determine what neuroimaging, neurocognitive, or other characteristics predict the development of post-deployment mental illness, and (3) to assess the longitudinal course of post-deployment mental illness. The study is taking place at WRAMC and VA VISIN 6 (Veterans Integrated Service Network – VA Mid Atlantic Health Care Network). *Performers:* Army (WRAMC) and VA
- ***The Effect of Written Emotional Expression on Depression Following Mild Traumatic Brain Injury:*** This effort investigates a cost-effective approach to reduce depression following mTBI. Emotional expression has been found to decrease depression in the short term in populations without head injury. It investigates the utility of this approach to reducing depression in a head-injured population. *Performers:* Air Force (59th Medical Wing Wilford Hall) and DoD
- ***Traumatic Brain Injury and Outcomes:*** This study characterizes TBIs among military personnel during the second phase of OIF from early in the medical chain of evacuation through Landstuhl Regional Medical Center. Data come from the Navy–Marine Corps CTR and includes both battle and nonbattle injuries. Follow-up of TBI patients is conducted to examine the short-term medical and personnel-related effects of TBI among those surviving. *Performer:* DoD (DVBIC)

Other Tissues and Organs

- ***3D Biomaterial Structures for Endothelial Cells Tissue Engineering Applications***: This project develops new 3D network formation technology based on a slowly degrading biocompatible biopolymer, silk fibroin. The focus is on building and testing a blood vessel network formed from the protein. *Performer:* Army (USAMRMC) and the Charles Stark Draper Laboratory, Inc.

- ***A Portable Physiological Fluid Warmer for Blood Infusion in Combat Injury:*** This project: (1) performs benchtop measurements of a device using surrogate biological fluids to optimize the operating specifications of the device, (2) performs in vitro studies using banked blood to predict device operability with real biological fluids, (3) utilizes the prototype device in animal studies using murine and swine models for gut injury, and (4) tests the device in a clinical setting with controlled administration of warmed fluids. *Performers:* Army (USAMRMC) and University of Texas Health Science Center at Houston
- ***A Multi-center, Randomized, Double-blind, Parallel Group, Placebo-controlled Trial to Evaluate the Efficacy and Safety of Activated Recombinant Factor VII (rFVIIa/NovoSeven®/ NiaStase® in the Treatment of Refractory Bleeding in Severely Injured Trauma Patients:*** This research evaluates the efficacy and safety of rFVIIa (NovoSeven/NiaStase) compared to placebo as an adjunct to standard treatment of trauma patients with active hemorrhage refractory to blood component therapy and surgical hemostatic procedures. *Performers:* Air Force (59th Medical Wing Wilford Hall) and Novartis
- ***Adult Stem Cells for Wound Healing and Immune Reconstruction:*** The project develops optimized antimicrobial coatings for medical devices such as external fixator pins for orthopedic stabilization in the field. The goal is to coat medical devices with robust coatings that have antimicrobial elution patterns covering a relevant time frame to prevent formation of biofilms while providing a surface that encourages osteo-integration. *Performers:* Army (USAMRMC) and Bacterin International Inc.
- ***Advanced Regenerative Medicine Skin Cell Therapies—Burn, Limb, and Digit Treatment:*** This project develops effective methods to generate replacement cells necessary for tissue repair or regeneration. *Performers:* Army (USAMRMC) and Pittsburgh Tissue Engineering Initiative
- ***Advanced Resuscitation Fluid:*** This effort focuses on the advanced clinical development of resuscitation fluids. *Performers:* Army (USAMRMC); National Heart, Lung and Blood Institute (NHLBI); Institutes of Health Research, Canada; and Defence R&D Canada (DRDC), Canada
- ***Advanced Technology Development in Tissue Engineering:*** This effort focuses on the clinical testing and validation of new candidate products and techniques for autologous growth of tissue for treatment of extremity wounds and to mitigate secondary tissue injury or infection. *Performer:* Army (USAMRMC)
- ***Angiogenesis and Tissue Engineering Research:*** This effort applies rapidly emerging knowledge of angiogenesis (blood vessel formation), tissue engineering, and biomaterials to clinical problems that heretofore could not be managed appropriately or ideally. *Performers:* Army (USAMRMC) and Children's Hospital Boston
- ***Applied Research in Tissue Engineering for Treatment of Bone/Soft Tissue Trauma:*** This effort evaluates and tests new candidate products and techniques for the re-growth of lost tissue for treatment of extremity wounds and to mitigate secondary tissue injury or infection. *Performer:* Army (USAMRMC)
- ***Automated Medical Emergency Intravascular Access:*** This effort will develop a semiautomated to fully automated ultrasound-based imaging, insertion, and placement system for the emergency placement of catheters within the descending aorta via a transthoracic or periphery artery approach for rapid infusion of cold flush solutions to induce emergency hypothermia or suspended animation. This project includes analysis of an added direct left ventricular catheter insertion approach as one additional option for rapid delivery of the cold flush. Also, the concept of a fully automated SmartCath/AutoCath system including 3D real-time electronic ultrasound scanning, and acquisition of vascular images is being further explored for development. Further, the potential for an automated catheter insertion drive mechanism to complete full automation is being conceptualized and explored for feasibility based on currently available mechanical and robotic technologies.

Performers: Army (USAMRMC), Alion Science & Technology, Safar Center for Resuscitation Research, and University of Pittsburgh

- ***Battlefield Exercise and Combat-related Spinal Cord Injury Research:*** This project investigates the pathophysiology of SCI with the major goal of developing therapies targeted at both the acute and more chronic injury setting. The overall hypothesis is that high-content screening of available libraries containing hundreds to thousands of chemicals, small molecules, and small interfering RNAs will lead to the identification of novel strategies to reduce cell death and improve axonal regeneration following SCI. *Performers:* Army (USAMRMC) and University of Miami
- ***BioFoam Bleeding Sealant for Battlefield Trauma:*** The objective of this effort is to provide the warfighter, medic, and combat surgeon with a hemostatic agent that is effective, easily applied, lightweight, easily transported, generates no heat, and has no special storage requirements. A protein hydrogel formulation that meets such a criteria (BioFoam) has been identified and patents have been applied for the formulations and the uses. It needs to be further developed for FDA approval and battlefield use. This material will initially be developed for use during Damage Control Surgery at the Forward Surgical Team or Combat Support Hospital level. It is anticipated that its use will later be broadened to include medic- or self-administration and use on the extremities. *Performers:* Army (USAMRMC) and CryoLife, Inc.
- ***Biomarkers of Non-fatal Liver Injury***: The liver injury program generates novel biomarkers that can be examined in clinical samples obtained from blast victims. *Performers:* Air Force (HQ USAF/Surgeon General), Army (USAMRMC), and the State of Texas
- ***Bisphosphonate-ciprofloxacin Carried by or Tethered to Micron or Nanosized Hydroxyapatite Particles as a Prototype for Local Antibiotic Delivery to Injured Bone:*** In this prototype evaluation, Angstrom Medica will supply not less than 100 grams of NannOss particles per year. In addition, Angstrom Medica will conjugate E41 with NannOss. ElizaNor Biopharmaceuticals holds the patent for E41-materials. *Performers:* Army (USAMRMC), Angstrom Medica, Inc., and ElizaNor Biopharmaceuticals, Inc.
- ***Combat Casualty Care for Battlefield Wounds:*** This project conjugates antimicrobial and pain relief agents to the chitosan biopolymer backbone to increase the functionality of field-applied dressings and bandages. *Performers:* Army (USAMRMC) and Resodyn Corporation
- ***Combat Critical Care Engineering: Evaluation of Closed Loop Control of Fluid Infusion during Resuscitation in the Compensatory and Decompensatory Phases of Hemorrhagic Shock:*** This effort focuses on the investigation and development of automated life support algorithms for intravenous (IV) fluid delivery for resuscitation from hemorrhagic shock. This project developed automated life support algorithms for IV fluid delivery for resuscitation from hemorrhagic shock. *Performers:* Army (USAMRMC) and Industry
- ***Combat Critical Care Engineering: Evaluation of Closed Loop Control of Ventilation and Oxygen Flow During Resuscitation in the Compensatory and Decompensatory Phases of Hemorrhagic Shock:*** This effort evaluated closed loop control of ventilation and oxygen flow during resuscitation in the compensatory and decompensatory phases of hemorrhagic shock. This project developed automated life support algorithms for oxygen delivery and ventilatory support of the critically injured patient. *Performers:* Army (USAMRMC) and Industry
- ***Comparison of Patient Warming Strategies in Deployed Environments****:* This effort is evaluating the safety and efficacy of the Caswarm and ChillBuster patient warming devices in preventing heat loss in subjects (*Sus scrofa*) exposed to environmental conditions common in aeromedical transport and forward deployed locations. *Performer:* Air Force (59th Medical Wing Wilford Hall)

- ***Composite Titanium/Bioengineered Dental Tissue Implants:*** This effort seeks to bioengineer functional, biological replacement teeth from autologous tissues. Methods to augment currently used titanium implants with bioengineered dental tissues are proposed. The hybrid constructs consist of a titanium core surrounded by bioengineered enamel, dentin, cementum, and importantly, periodontal ligament to provide the hybrid implants with shock absorbing properties to reduce or eliminate bone resorption—a common cause of implant failure. *Performers:* Army (USAMRMC) and Forsyth Institute
- ***Control of Spinal Cord Injury by Stereotactic X-irradiation:*** This project determines the optimum conditions for opposing loss of locomotor function following contusion injury in rats with stereotactic x-irradiation. *Performer:* Army (USAMRMC)
- ***CRF Spinal Cord Injury Clinical Trials Research Initiative:*** The Christopher Reeve Foundation (CRF) proposes conducting clinical trials in a joint effort with military hospitals, VA hospitals, and the North American Clinical Trials Network (NACTN). *Performers:* Army (USAMRMC), CRF, NACTN, and VA
- ***Damage Control Resuscitation: Clinical Trial on Hypertonic Saline Dextran:*** This effort studied the individual and combined effects of existing and novel replacement fluids and artificial blood products to treat for shock and attendant multi-organ failure. The Resuscitation Outcomes Consortium, in collaboration with the NHLBI, opened enrollment for a clinical trial on Hypertonic Saline Dextran as a replacement fluid for trauma victims and developed plans for a trial of the Impedance Threshold Device. *Performers:* Army (USAMRMC), NHLBI, and Canadian Defense Forces
- ***Damage Control Resuscitation: Coagulation Profiles and Clotting Disorders*:** Studied the individual and combined effects of existing and novel replacement fluids and artificial blood products to treat for shock and attendant multi-organ failure. These studies included the use of fresh whole blood and blood components in experimental animals and results of the change in clinical practice guidelines in theater. It also included studies of coagulation profiles and clotting disorders in experimental animals and humans in response to hemorrhage and traumatic injury including burns. The studies resulted in the fielding of the Golden Hour Container for transport of fresh blood and the development of a method to freeze dry plasma. *Performer:* Army (USAMRMC)
- ***Damage Control Resuscitation: Collaboration on Resuscitation and Hemorrhage Control:*** This project combines previous program areas of hemorrhage control, blood products, and resuscitation and provides an integrated approach to treatment of severely wounded casualties. The individual and combined effects of existing and novel replacement fluids and artificial blood products to treat for shock and attendant multi-organ failure are studied. This includes the NHLBI collaboration on resuscitation and hemorrhage control. *Performers:* Army, NHLBI, and Canadian Defense Forces
- ***Damage Control Resuscitation: Complement Activation Inhibitors:*** The studies provided an integrated approach to treatment of severely wounded casualties and assessed individual and combined effects of existing and novel replacement fluids and artificial blood products to treat for shock and attendant multi-organ failure. Includes complement activation inhibitors. The studies resulted in testing of complement activation inhibitors in large animal models. *Performer:* Army (USAMRMC)
- ***Damage Control Resuscitation: Far-Forward Fluid Resuscitation:*** Included studies in experimental animals investigating far-forward fluid resuscitation with solutions other than blood products. The study led to the selection of Hextend as the fluid of choice for shock victims. *Performer:* Army (USAMRMC)

- ***Damage Control Resuscitation: Studies of Hemostatic Dressings and Drugs:*** This project provides an integrated approach to treatment of severely wounded casualties and includes studies of hemostatic dressings and drugs, including recombinant Factor VIIa (rFVIIa) in animal models of hemorrhage without or with a concomitant coagulopathy. The studies resulted in the fielding of the Chitosan hemostatic dressing, the Combat Applications Tourniquet, and the in theater use of rFVIIa as an aid to clotting. *Performers:* Army (USAMRMC), NHLBI, and Canadian Defense Forces
- ***Damage Control Resuscitation: Tactical Combat Casualty Care (TCCC):*** This effort tailors first responder treatment to better fit the constraints of the modern battlefield. The project resulted in the publication of new TCCC guidelines that were subsequently approved by the American College of Surgeons and incorporated as chapter 16 of the Civilian Pre-Hospital Trauma Life Support manual. *Performers:* Army (Special Operations Command), Navy, and Marine Corps
- ***Determining the Effects of a Polymerized Bovine Hemoglobin Blood Product Substitute (HBOC-201) on Wound Healing in a Rodent Model (Sprague Dawley):*** This effort will determine the effects of HBOC-201 on wound healing, specifically leading to decreased tensile strength and hydroxyproline content. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Development and Maintenance of Surgical Skills for Field Operational Surgery and Field Assessment and Skills Tests for Air Force Unit Type Codes or Deployable Assemblages Using the Pig (*Sus scrofa*) and the Goat (*Capra hircus*):*** This effort trains and assesses members of USAF deployable unit type codes (UTCs) on the performance of general surgical and medical procedures and casualty management required for the care of patients in a field setting or during evacuation. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Development of an Injectable, Self-assembling Engineered Myocardium:*** This effort focuses on tissue engineering of myocardial tissue to locally repair myocardium and improve cardiac function. *Performers:* Army (USAMRMC) and Center for Integration of Medicine and Innovative Technology
- ***Development of Transcutaneous Infection Prevention Protocol:*** This study is developing a durable, infection-free, osseointegrated implant for direct skeletal attachment of the prosthesis to a human. The researchers are using porous implants to create soft-tissue ingrowth as well as create an antimicrobial reservoir on the implant using Formula 5 or pexiganan acetate. Specific aims are to determine if (1) the antimicrobial agents prevent infection in a rabbit model, (2) porous-coated tantalum pins with the soft tissue ingrowth barrier can prevent infection compared to smooth pins, and (3) the test agents cause skin irritations in humans. *Performers:* Army (USAMRMC), Western Institute for Biological Research, and University of Utah Orthopedic Center, Department of Orthopedics
- ***Effects of Recombinant Human Erythropoietin on the Treatment of Blunt Spinal Cord Injury Utilizing a Rat Model:*** This study is administering recombinant human erythropoietin following blunt SCI to determine: (1) if there is a difference in the volume of the spinal cord lesion between groups treated with methylprednisolone, rhEPO (two different doses) or a combination of methylprednisolone and rhEPO versus untreated animals, and (2) if the timing of rhEPO dosing affects the volume of the spinal cord lesion (as measured by the sodium-potassium concentration levels) in treated animals. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Extended Life Red Blood Cells:*** This effort focuses on advanced clinical development for extended life of red blood cells. *Performers:* Army (Armed Services Blood Program Office), Hemerus Medical, LLC, University of Cincinnati, and American Red Cross
- ***Hemostatic Agents—Demonstration of Product to Control Internal Hemorrhage due to Blunt or Penetrating Trauma:*** This effort demonstrates hemostatic control of severe internal hemorrhage without surgical access. *Performer:* Navy (Office of Naval Research)

- ***Hemostatic Dressing:*** This effort develops the dressing, sets up a production line, and fields the product. *Performers:* Army (USAMRMC), Oregon Medical Laser Center, and HemCon, Inc.
- ***Hibernation Genomics:*** This project seeks to: (1) develop comprehensive genomic resources for use in gene discovery related to metabolic suppression and organ stabilization in the black bear and Arctic ground squirrel; (2) determine the cellular and molecular basis for preventing cardiac arrhythmias under conditions that produce arrhythmias in humans and for protecting the brain from injury due to cardiac arrest or stroke; and (3) expand infrastructure for breeding and maintaining two hibernating species, the black bear and the Arctic ground squirrel. *Performers:* Army (USAMRMC) and University of Alaska, Fairbanks
- ***Individual Oxygen Generator:*** These efforts develop an oxygen generator, set up a production line, and field the product. *Performers:* Army (USAMRMC), IGR Enterprises, Inc.; and SeQual, Inc.
- ***Institute of Bioengineering and Nanoscience in Advanced Medicine (IBNAM):*** This research assesses the ability of polymeric and supramolecular hydrogels designed to deliver DNA and growth factors to recruit endothelial cells in vitro and in vivo, promoting angiogenesis, revascularization, and wound healing. The sensitivity and selectivity of semiconducting single-walled carbon nanotubes encapsulated with amphiphilic surfactants, peptide amphiphiles, or DNA are evaluated and parameters determined to induce the nanotubes to function as sensors that target and selectively react with militarily significant chemical or biological agents. *Performers:* Army (USAMRMC) and Northwestern University
- ***IV Fluid Warmer:*** This effort develops the IV fluid warmer, sets up a production line, and fields the product. *Performers:* Army (USAMRMC) and Enginivity, Inc.
- ***Mechanism of Heterotopic Ossification in Traumatic Injury:*** This study investigates the key factors contributing to the development of heterotopic ossification (HO) in soldiers who have sustained traumatic war injuries. Combining clinical data with in vitro experiments provides insight to the mechanism of HO development and allows testing of potential targets for HO prevention. *Performer:* Army (USAMRMC and WRAMC)
- ***Medical Pneumothorax Device (PTX):*** This effort develops a portable device that detects the presence of pneumothorax (collapsed lung) in a combat casualty. This device is envisioned to be lightweight and easy to operate allowing the combat medic to carry and use the device in the treatment of casualties. *Performers:* Army (USAMRMC) and Stethographics, Inc.
- ***Military Biomaterials Research (CeMBR):*** This effort creates a Center for Military Biomaterials Research (CeMBR), which is a network of academia, industry, and the military that provides rapid and effective pathways for identification, development, and utilization of biomaterial-based technologies and products that specifically target the military's most urgent health care needs on and off the battlefield. CeMBR functions by blending new science, technology, and clinical practices with the desired goal of producing biomaterial-based products ready for clinical trials and commercialization. *Performers:* Army (USAMRMC) and Rutgers, the State University of New Jersey, Center for Biomaterials
- ***Nanofabricated Bioartificial Kidney:*** This effort applies and fuses the rapidly emerging knowledge and methods of stem cell technology with microelectromechanical systems to produce a bioartificial kidney that can eventually be used as a replacement for damaged or weakened kidneys. *Performers:* Army (USAMRMC), Innovative BioTherapies, Inc., Cleveland Clinic, University of Michigan, and Nephros Therapeutics

- ***National Heart, Lung, and Blood Institute Collaboration—Resuscitation Outcomes Consortium:*** Apply for Investigational New Drug (IND) status for a candidate resuscitation fluid(s) or drugs and to conduct early clinical studies of candidate fluids, drugs, and/or biological agents for treatment of fluid loss in battlefield casualties. *Performers:* Army and NHLBI, and a consortium of 11 clinical trial centers including 2 in Canada
- ***Pharmacologic Intervention to Reduce Morbidity and Mortality Following Trauma, Hemorrhage, Burn, Fracture, and Sepsis:*** This effort investigates the ability of thiazolidinedione treatment to prevent or reduce mortality following injury alone or when the primary injury is combined with a septic challenge that often develops following acute injury. *Performer:* Army (USAMRMC)
- ***Platelet-derived Hemostatic Agent:*** This effort conducts transitional development and advanced clinical development of platelet-derived hemostatic agents. *Performers:* DARPA, Naval Medical Research Center, Armed Services Blood Program Office, and Cellphire Corporation
- ***Rapid Wound Healing Technology Development Project:*** This effort investigates new techniques and approaches for discovering solutions for peripheral nerve damage, tissue loss, bone regeneration, and hemorrhagic disorders. *Performers:* Army (USAMRMC), Stemnion, LLC, and Pittsburgh Tissue Engineering Initiative
- ***Regional Anesthesia and Pain Management Initiative:*** The objectives of this effort are: (1) the continued development of advanced peripheral nerve block and continuous peripheral nerve block anesthetic techniques in the management of acute and chronic pain in patients and (2) the integration of traditional and nontraditional pain management modalities. *Performers:* HMJF, Conemaugh, and Army (WRAMC)
- ***Remote Acoustic Hemostasis/Image-guide High Intensity, Focused Ultrasound (HIFU) Therapy:*** This program increases understanding of the use of HIFU in arresting vascular and capillary bleeding from trauma to develop and refine methods and devices for HIFU treatment of trauma, and to study the short- and long-term effects of HIFU therapy. *Performers:* Army (USAMRMC), University of Mississippi, and University of Washington
- ***Resuscitation from Hemorrhage Using HBOC-201 (Hemopure) in the Setting of Brain Injury: Evaluation of Cerebral Injury Volume, Cerebral Edema, Cerebral Blood Flow and Reactivity, and Histopathology in a Rat Model of Traumatic Brain Injury and Hemorrhagic Shock:*** This effort is determining if there are differences in cerebral edema and volume of cerebral injury at 24-hours post-injury between the control group (no cerebral injury/no hemorrhage) and any of the treatment groups or between treatment groups. In addition, it is determining if there are differences in the physiological indices during the resuscitation period between the control group and any of the treatment groups or between treatment groups. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Retrospective, Institutional Review of Vascular Trauma: Assessment of Injury Patterns, Resource Utilization, and Treatment Outcomes:*** This effort will streamline the care of trauma patients sustaining injuries to the cardiovascular system, with the goal of improving patient care and making more efficient the use of facility resources. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Safety and Efficacy of Selective Optical Stimulation for the Damaged Nervous System:*** This project uses prosthetic devices that stimulate neurons to restore lost function; they can also accelerate nerve regeneration and reduce muscle atrophy and pain. Traumatic injury to the nervous system leads to loss of limb function and frequently, persistent pain. Clinical management of nerve injury, including immobilization of the affected area and surgical grafts, are often not sufficient to promote recovery of function. *Performer:* Army (USAMRMC)

- ***SuperQR Powder Development:*** This project assesses the potential of SuperQR dressings developed using the quick relief (QR) Technology Platform to control severe hemorrhage and the viability of a delivery device containing SuperQR dressing in providing hemostasis control in animals during preclinical and clinical studies. *Performers:* Army (USAMRMC) and Biolife, LLC
- ***Surgical Wound Disinfection and Biological Agents:*** This project extends the scope of efficacy and safety studies in animals to support an IND filing with FDA. Dosing, volume, and treatment regimen studies are conducted to formulate the myeloperoxidase system for use in the Walker-Mason and excision-related animal models. These studies will be conducted at the Southern Research Institute and Ricerca Laboratories. Additional safety studies are conducted by contract laboratories and will include sensitization, toxicity, pharmacokinetic, and genotoxicity studies in multiple animal species. Preclinical in vivo efficacy studies are conducted in small and large animal models at the U.S. Army Institute of Surgical Research (USAISR). *Performers:* Exoxemis Inc. and Army (USAISR)
- ***The Effect of Subatmospheric Pressure Dressings and High-pressure Pulsatile Lavage on the Formation of Heterotopic Bone in a Rabbit Model:*** The project is determining (1) the effect of serial irrigation and debridement procedures on the formation of heterotopic bone in a rabbit model, (2) the effect of subatmospheric wound dressings on the formation of heterotopic bone in a rabbit model, and (3) the effect of serial irrigation and debridement procedures used in combination with subatmospheric wound dressings on the formation of heterotopic bone in a rabbit model. *Performers:* Army (USAMRMC) and Navy (National Naval Medical Center)
- ***Thoracostomy Tube Insertion Instruction and Training Utilizing a Rabbit (*Oryctolagus cunniculus*) Model:*** This effort trains and assesses members of USAF deployable UTCs on the performance of general surgical and medical procedures and casualty management required for the care of patients in a field setting or during evacuation. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Tissue Replacement and Repair for Battlefield Injuries:*** Efforts are under way to fashion tissue substitutes using biologic biomaterials that will repair wounds. The tissue substitutes are formed from various elastin formulations, which have been shown to be relatively biologically and chemically inert and to have poor cross-species antigenicity. The tissue substitutes are fused to the wound by either a low-powered laser, using dye to target the laser energy to the elastin tissue interface, or cyanoacrylate glue. *Performers:* Army (USAMRMC) and Oregon Biomedical Engineering Institute
- ***Vascular Graft Development on Elastin Biomatrices:*** Several efforts are developing a functional tissue-engineered elastin xenograft (graft from different species) for vascular graft therapy into patients requiring reconstructive surgery of limbs or tissues damaged in the battlefield or for patients with vascular disease in need of vessel replacement for small diameter (<6 mm) vessels. *Performers:* Army (USAMRMC), Tissue Genesis, Inc., MPR Associates, University of Arizona, and International Heart Institute of Montana

Modeling, Simulation, Test, and Evaluation

- ***Acellular Human Tissue Matrix Research: Matrix-mediated Regeneration of Orthopedic Tissues for Military Applications:*** This project tests LifeCell's hybrid ACL (anterior cruciate ligament) graft using a robotic model of 3D, natural knee kinematics. The project entails recording normal porcine knee motions using piezoelectric sensors and differential transducers to measure. *Performers:* Army (USAMRMC), University of Cincinnati, and Frontier Biomedical
- ***Advanced Technology Development of Medical Simulators for Training:*** This effort validates the integration of simulator components and associated haptic technology into a virtual reality simulator prototype that substantially enhances capability to train field medical personnel. *Performers:* Army (USAMRMC) and Industry

- ***Applied Research in Medical Simulators for Training:*** A joint collaboration between USAMRMC and the U.S. Army Research, Development, and Engineering Command (RDECOM) funded a contract with METI Inc. to build a new, less-expensive, self-contained simulator to better train medics. Three first generation prototypes are being evaluated by medic training schools. The results of that evaluation will be incorporated into a second generation model that should be commercializable. *Performer:* Army (USAMRMC and RDECOM)
- ***Biomechanical and Metabolic Analysis of Amputees Carrying Military Loads to Meet Return to Duty Requirements:*** This study quantifies the metabolic and biomechanical responses of unilateral, transtibial amputees while they walk at two velocities with a minimal load on the body and while carrying two military loads that differ in weight and in composition and contrasts the responses with those of individuals without limb loss. A secondary objective is to evaluate the kinematic effects of these battle loads. The energy cost of locomotion in an unburdened state is higher among amputees than among individuals with no limb loss. The heavy loads, combined with a higher energy cost of locomotion, may prevent transtibial amputees from participating in military load-bearing activities. *Performer:* Army (Natick Soldier Center, WRAMC, and USAMRMC)
- ***Blast Protection for the Individual Warfighter (The Technical Cooperation Program, Project Arrangement No PA-1/05/WPN):*** The USAMRMC is working with defense organizations from the United States, United Kingdom, Canada, and Australia to develop and demonstrate an integrated system that will protect the individual warfighter from ballistic and blast threats, including blast from thermobaric weapons. The four nations are performing this work under the auspices of The Technical Cooperation Program (TTCP in a 5-year Project Arrangement (PA). The USAMRMC brings a wealth of blast bioeffects knowledge and several unique tools to bear on this challenging task. These biomedically based tools include a blast injury prediction model, known as "INJURY," and a behind body armor blunt trauma injury prediction model and testing device. The Military Operational Medicine Research Program also has an extensive blast injury bioeffects database containing data from nearly 50 years of blast bioeffects research. The PA will enable the four nations to exchange information and equipment and to participate in joint tests. *Performers:* Defence Science and Technology Laboratory (DSTL), United Kingdom; DRDC-Valcartier; Army (USAMRMC and Natick Soldier Center); Defence Science & Technology Organisation, Australia
- ***Body Armor Blunt Trauma Assessment:*** This effort provides body armor developers with the tools they need to produce lighter, more comfortable body armor systems. It produces a biomedically valid, user-friendly, and cost-effective body armor blunt trauma testing method. The testing method includes an anthropomorphic test module and injury prediction software. The research includes carefully controlled animal injury tests with advanced medical imaging techniques and advanced mathematical modeling techniques. *Performer:* Army (USAMRMC)
- ***Centers for Sustainment of Trauma and Readiness Skills:*** The centers provide ongoing readiness skills training and refresher program with didactic teaching of blast injury management combined with human patient simulator scenarios specific to blast and evaluation and management of actual trauma patients. *Performers:* Air Force (HQ USAF/Surgeon General) and University of Maryland Medical System R. Adams Crowley Shock Trauma Center
- ***Compartment Syndrome Simulator:*** A simulation system to teach medical personnel recognition and management of compartment syndrome (CS) using top-of-the-line military, civilian, and technological experts. Phase 1 initiates the process by which analysis, design, construction, and evaluation of a desktop immersion system for the teaching of CS diagnosis and treatment can be implemented. *Performers:* Army (USAMRMC) and SimQuest LLC

- ***Compartment Syndrome Simulator—Touch of Life Technologies:*** TolTech is designing a realistic and adaptive, virtual reality-based simulator for training diagnostic and surgical skills related to CS. The simulator uses haptic and graphic display to give the student the experience of feeling and seeing the interaction of virtual tools, including scalpels, forceps, retractors, and fingers with the virtual patient. *Performers:* Army (USAMRMC) and Touch of Life Technologies
- ***Determine the Physiological Consequences to the Eye Resulting from Blunt Trauma Injury—(Validate Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools):*** This effort conducts modeling of blunt trauma impacts to the facial bone structure for determination of material solutions to enhance protection. *Performers:* Army (USAMRMC) and Wake Forest University
- ***Development of a Physiological and Performance Assessment Tool Following Blast Injury Exposure—(Validate Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools):*** This effort refines blunt trauma prediction initiatives of physical and performance decrements using software modeling technologies. *Performers:* Army (USAMRMC) and L-3 Communications/Jaycor
- ***Educational Intervention on Combat Trauma Care:*** This effort trains and assesses members of USAF deployable UTCs on the performance of general surgical and medical procedures and casualty management required for the care of patients in a field setting or during evacuation. *Performer:* Air Force (59th Medical Wing Wilford Hall)
- ***Fractured Femur Simulator:*** This project modifies the Melerit Trauma Vision simulator to include more functionality and to be more realistic. Simulution, Inc. is working with Melerit Medical AB of Sweden to create a femur fracture simulator to train military and civilian orthopedic surgeons and other medical personnel. The Melerit Trauma Vision simulator, a part task, virtual reality simulator, already allows surgeons to practice installing internal fixators including screws, pins, and hook into a virtual femur while watching simulated fluoroscopic images. *Performers:* Army (USAMRMC) and Simulution, Inc.
- ***Fractured Femur Simulator—Touch of Life Technologies—Phase 2:*** This project is developing a fractured femur simulator that uses advanced graphic and haptic displays, as well as the data from the Visible Human Male, to portray various patient scenarios with varying complexity of femoral trauma. The simulator incorporates features such as transparency, fluoroscopy, and simulated ultrasound. *Performers:* Army (USAMRMC) and Touch of Life Technologies
- ***Gait Analysis of Military Amputees with Traumatic Transfemoral Amputation:*** This study identifies gait characteristics of otherwise healthy military subjects with transfemoral amputations and determines the effects of residual limb lengths on gait parameters. Information available in the literature is incomplete relative to the effects of residual limb length on kinematics in transfemoral amputees, and virtually no information is available investigating the effects of residual limb lengths on gait kinetics. *Performers:* HMJF and Army (WRAMC)
- ***Head/Helmet Acceleration Measurement and Human Modeling for Injury Assessment from Blast:*** This effort is developing inexpensive technologies to measure head/helmet accelerations in the field for TBI risk identification and injury modeling. *Performer:* Air Force (HQ USAF/Surgeon General)
- ***Individual Protection against Novel Blast Threats:*** This effort focuses on development of BOP protection from primary blast lung injury to be used in conjunction with current and future body armor systems. *Performers:* Army (USAMRMC), Navy (Naval Surface Warfare Center – Indian Head), Army Research Laboratory, Canada, Australia, and UK under TTCP Project Arrangement

- ***Intracranial Hematoma/Burr Hole and Trauma Flap Simulator:*** This effort develops a novel, hybrid, virtual workbench simulator. The simulator combines both haptic and tactile feedback with co-registered 3D stereoscopic visuals. The Phase 1 proposal has two objectives. The first develops a demonstration prototype to prove the hybrid concept. The second develops a design document for an open surgery simulator, using intracranial hematoma simulation as the driving problem. *Performers:* Army (USAMRMC) and Verefi Technologies
- ***Medical Modeling and Simulation—Exsanguinating Hemorrhage from Limbs:*** This project is designing and developing a hybrid mannequin simulator for training military medical personnel and Special Forces in the control of limb hemorrhage. A group of clinical experts from the military are guiding the selection of wounds to be simulated and providing input to the task analysis of skills and procedures that must be mastered for effective treatment. Performance metrics are being developed to discriminate among novice, adequate, and expert users with an emphasis on the development of case scenarios that can differentiate cognitive and technical skills related to knowledge, skill, and judgment. *Performers:* Army (USAMRMC) and SimQuest LLC
- ***NATO Task Group on behind Armor Blunt Trauma (BABT) (KTA 1-38):*** The BABT Task Group's purpose is to define the problem of blunt trauma behind body armor, including head trauma, and to propose testing methods for body armor developers. *Performers:* DRDC-Valcartier; DSTL, United Kingdom; Army (Natick Soldier Center); and National Institute of Standards and Technology
- ***Regional Anesthesia Simulator for Training of Resident and Staff Pain Management Specialists—Energid:*** The effort focuses on a training system that includes instructional content in a standard, configurable framework and immersive simulation of procedures to reinforce the instructional content. It leverages existing medical simulation technology being developed for the Army and develops a novel portable magneto-rheological (MR)-based haptic device appropriate for regional anesthesia simulation. The device provides high-fidelity force feedback for needle insertion and injection and will be particularly beneficial to battlefield regional anesthesia training. *Performers:* Army (USAMRMC) and Energid Technologies
- ***Regional Anesthesia Simulator for Training of Resident and Staff Pain Management Specialists—Touch of Life Technologies:*** This effort designs a realistic and adaptive, virtual reality-based simulator for practicing regional anesthesia skills on any part of the human body. The simulator uses haptic and graphic displays to give the student the experience of feeling and seeing the interaction of each tool, including needles, with the virtual patient. The simulated patients are derived from the Visible Human and respond to both nerve stimulation and drug-induced blockage in response to the position of the needle tip when either stimulation is applied or anesthesia injected. The simulator will be combined with a mentor program that will guide and test the development of the student. *Performers:* Army (USAMRMC) and Touch of Life Technologies
- ***Release of Blast Lung Injury Prediction Tool Known as "INJURY 8.1":*** INJURY 8.1 is the product of over 20 years of BOP research. The research involves extensive tests in the field to collect injury data in large animals, laboratory tests to determine the material properties of the body and its tissues, and the development of comprehensive finite element mathematical models of the body's response to blast and the processes by which that response leads to internal injury. *Performer:* Army (USAMRMC)
- ***Release of Blast Lung Injury Prediction Tool Known as "INJURY 8.2":*** The latest version of the blast lung injury prediction tool, INJURY 8.2, incorporates several new modeling and software features. Version 8.2 takes into account the thoracic geometry differences between man and sheep, the primary large animal species used in previous field tests. The model also allows orientation effects to be accounted for. Injury correlations were updated based on additional large animal data. The software allows for batch processing of large numbers of test data in a single session. *Performer:* Army (USAMRMC)

- ***Release of Source Code for the Blast Lung Injury Prediction Tool Known as "INJURY 8.1":*** The source code for this latest version of INJURY was packaged and released to the U.S. Army Research Laboratory's Survivability and Lethality Analysis Directorate to support their Survivability, Lethality, and Vulnerability Analyses mission. *Performer:* Army (USAMRMC)
- ***Release of Toxic Gas Analysis Software (TGAS) 2.0P:*** The TGAS 2.0P is the latest version of software to predict immediate and delayed effects of inhalation of toxic fire gases, such as those gases generated in armored vehicle crew compartments when the vehicle's armor is defeated. The TGAS model is the product of nearly a decade of inhalation toxicology research. The research involved a comprehensive review and recovery of animal and human data on toxic gas effects over the past 50 years, extensive animal tests in the laboratory, and the development of advanced physiologically based mathematical models. The latest version of TGAS provides an estimate of the probability of incapacitation and lethality from any combination of seven common fire gases. *Performer:* Army (USAMRMC)
- ***SITE, Transparent Armor:*** This effort develops enhanced transparent armor materials for increased mass efficiency and improved durability for personnel (face and eye) protection. *Performers:* Army (USAMRMC and U.S. Army Research Laboratory), Paulson Manufacturing, Infoscitex, and PPG Industries
- ***Tactical Combat Casualty Care*** (***TC3) Game:*** The TC3 Simulation uses game engine-based technology to provide an engaging, relevant, virtual training environment for training Army Medics. Trainees are immersed in a realistic virtual scenario and must demonstrate both their soldier and medical skills to successfully complete the training event. Trainees must assess casualties, prioritize treatment, treat various types of trauma injuries, and prepare the casualties for evacuation. Funding is expanding the capabilities of the application beyond the classroom. Enhancements include courseware, distance learning capability and an After Action Review (AAR). Types of casualties include: limb amputation, maxo-facial injuries, gunshot wounds, tension pnuemothorax, burns, and deceased. *Performers:* Army (USAMRMC, AMEDD C&S, and U.S. Army Research Institute) and Industry (ECS).
- ***US–UK Information Exchange Agreement (IEA) on Novel Explosives (NE):*** This IEA was established between the Defense Threat Reduction Agency (DTRA) and the DSTL as a vehicle for exchanging information (up to the Secret level) on NE development and survivability. USAMRMC is a participating organization in this IEA. A primary focus is the sharing of information on blast injury prediction models to develop effective warfighter protection systems. *Performers:* DTRA; DSTL, United Kingdom; and Army (Natick Soldier Center)
- ***USAMRMC and National Highway Traffic Safety Administration (NHTSA) Collaborative Agreement on Blunt Trauma Injury Models:*** The USAMRMC and NHTSA are interested in developing biomedically valid blunt trauma injury prediction tools. The USAMRMC's focus is on developing tools to guide the development of effective soldier protection systems like body armor. The NHTSA focus is on the development of vehicle crash safety standards. The underlying human injury prediction models are the same. Under this collaborative agreement, the organizations share information and leverage each others research efforts to develop valid blunt trauma injury tools. *Performers:* NHTSA, L-3 Communications/Jaycor (under contract to the USAMRMC)
- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Assess TBI Effects Resulting from Blunt Impact Injury):*** This effort uses advanced electronics to record TBI consequences during high-risk activities. *Performers:* Army (USAMRMC) and Wayne State University

- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Conduct Facial Injury Protective Material Assessment):*** This effort conducts experimental assessments of materials used to protect the face from blast injuries. *Performers:* Army (USAMRMC) and Virginia Polytechnic Institute and State University
- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Determine Blast Related Injuries to Components of the Eye):*** This effort conducts studies of the eye under various blast conditions to assess the potential for injury. *Performers:* Army (USAMRMC) and Virginia Polytechnic Institute and State University
- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Develop Face and Eye Injury Models):*** A face model is being developed with detailed representation of the facial bones to determine blast injury effects. *Performers:* Army (USAMRMC) and Wake Forest University
- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Develop a Manikin to More Accurately Assess Blast-related Face and Eye Injury):*** This effort will develop a test manikin with integrated sensors capable of accurate and repeatable measurement of face and eye physiological changes due to blast effects. *Performers:* Army (USAMRMC) and Virginia Polytechnic Institute and State University
- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Develop Models for Blunt Trauma and Performance Assessment):*** This effort will develop a validated predictive software model for the physiological consequences of blast and blunt trauma injury. *Performers:* Army (USAMRMC) and L-3 Communications/Jaycor
- ***Validation of Combat Injury Prevention Strategies, Blast and Blunt Trauma Injury Prediction Tools, and Occupational Health Risk Assessment Tools—(Develop Novel Material Solutions to Provide Enhanced Eye Protection from Blast Exposure):*** This effort employs an innovative methodology to examine physiological reactions of the eye to blast impacts. Results will aid in the development of improved material for eye protection. *Performers:* Army (USAMRMC) and Virginia Polytechnic Institute and State University
- ***Wartime Competencies for the USAF Nurse: Training for Sustainment:*** This effort consists of a training protocol for Wartime Competencies for the USAF Nurse to provide improved nursing skills in managing blast and other combat injuries. *Performer:* Air Force (59th Medical Wing Wilford Hall)

Extremity

- ***A Powered Foot and Ankle Prosthesis for Improved Maneuverability and Reduced Metabolic Cost:*** This Phase 1 STTR addresses the need for development and implementation of novel-powered prosthetic foot–ankle components that can by used by military personnel with lower-limb loss in typical military and civilian environments. A cost-effective, biomemetic, dynamic foot–ankle system is proposed that improves balance, walking speed, gait metabolism, and prosthesis control compared to current passive foot–ankle technologies. The system is being developed for use by military and civilian personnel in situations that include stair ascent and descent and uneven terrains. *Performers:* Army (USAMRMC) and Simbex
- ***Advanced Multi-axis Control System Using Blind Source Surface EMG:*** IntraGraphix, LLC uses Blind Source Separation signal processing techniques to create a novel multiaxis controller for prosthetic limbs based on surface EMG (electromyographic) electrode array recordings. In

Phase 1, the effort outfits normal subjects and transradial (below elbow) amputees with surface EMG electrode arrays, and the signals from these electrode arrays are processed and displayed in real time for training and performance analysis. *Performers:* Army (USAMRMC) and IntraGraphix, LLC

- ***Center for Traumatic Amputee Rehabilitation and Research:*** This project identifies the state of the research supporting evidence-based traumatic amputation rehabilitation with a prioritized research plan to strategically direct future resources and recommend appropriate infrastructures. The Indiana-Ohio Center for Traumatic Amputee Rehabilitation Research will survey veterans with a traumatic amputation, conduct a systematic analysis of the present knowledge base, and develop a 5-year prioritized plan for health services and functional limitations research that provide direction to rehabilitation as a necessary component of a high-quality Traumatic Amputee Quality Enhancement Research Initiative. *Performers:* Army (USAMRMC), Indiana University, and Ohio State University
- ***Development of a C-Leg Version with Optimized Functionality for Use in Extreme Situations:*** This project is developing a hardened microprocessor knee prosthesis with enhanced durability, increased strength, longer battery life, field recharging features, secure electronic function, which is also serviceable and patient adjustable. In addition, this project includes an add-on for a clinical trial of the new leg in association with Prosthetics Research Study (Seattle, Washington). *Performers:* Army (USAMRMC) and Otto Bock Healthcare Products
- ***Development of Advanced Military Prosthetic Shoulder System:*** Sarcos Research Corporation is developing a high-performance, ActiveShoulder™ military prosthetic system that will enable integration of upper extremity prostheses for performing, to the maximum extent possible, the basic functions of a natural arm. Phase 1 focuses on the development of system specifications document and kinematic and dynamic analyses that precedes the engineering design of the prosthesis. In the Phase 1 Option, Sarcos will assemble and demonstrate the feasibility of key design features of the arm, and in Phase 2, the team will focus on the design, testing, and regulatory approval of the proposed system. *Performers:* Army (USAMRMC) and Sarcos Research Corporation
- ***Energy-scavenging Ankle Component for Self-charging Batteries on Prosthetic Limbs:*** KCF Technologies Inc. is developing an energy-scavenging device as a component in the ankle of a lower extremity prosthetic limb. The component will be designed and demonstrated on a C-Leg, in collaboration with Otto Bock USA. The component will capture and store energy during normal activities such as walking and running. The captured energy will automatically recharge the batteries of the C-Leg. This energy will greatly extend the operational time of a battery charge or eliminate the need for battery charge altogether. In Phase 1, KCF will model, develop, fabricate, and test a prototype energy harvesting ankle component in laboratory demonstrations. *Performers:* Army (USAMRMC) and KCF Technologies, Inc.
- ***Evaluating the Presence of Compassion Fatigue among Health Care Providers Caring for Traumatic Amputees:*** This study assesses the presence of Compassion Fatigue among the nursing staff assigned to WRAMC Nursing. This investigation is a necessary first step to determine if interventions are needed. A secondary purpose of the study is to evaluate the reliability and validity of data collected with the instruments among nurses working in a military setting. This is a descriptive and correlational study to survey all nursing staff at WRAMC. *Performer:* Army (USAMRMC and WRAMC)
- ***High-functionality Energy-efficient Prosthetic Limbs Using Multi-functional Materials:*** Infoscitex Corporation is developing a regenerative energy system for lower limb prosthetics using electroactive polymers to extend the life and reduce battery weight for prosthetics. Infoscitex has teamed with the Cleveland Clinic and their artificial exo-tendon team to determine biomechanically optimum locations for these electroactive devices and make the necessary

advances in flexible electrode technology for future commercialization. *Performers:* Army (USAMRMC), Infoscitex Corporation, and Cleveland Clinic

- ***Microprocessor vs. Hydraulic-controlled Prosthetic Knee in Early-stage Rehabilitation for Transfemoral Amputees: A Pilot Study:*** Pilot data are collected in preparation for a definitive study that will compare functional outcomes in a young cohort with traumatic limb loss using either a microprocessor-controlled prosthetic knee or a hydraulic knee during early rehabilitation. *Performer:* Army (USAMRMC and WRAMC)
- ***Military Amputee Intramural Research Program:*** This program is developing a comprehensive, reliable, flexible research management organization infrastructure to provide an administrative and clinically useful research tool to support the Amputee Center's mission of improving the quality of life of active duty and veterans with amputated limbs. The specific aim of this research initiative is to support and augment the core research activities and facilities of the Amputee Center, WRAMC, developing and exploiting advances in surgical procedures, rehabilitation processes, and new prosthetic devices by providing the necessary essential infrastructure, personnel, and administrative and programmatic services to improve and sustain the quality of life of service men and women with amputated limbs. *Performers:* HMJF and Army (WRAMC)
- ***Military Extremity Trauma and Amputation/Limb Salvage (METALS) Study:*** This research examines the short- and long-term outcomes of U.S. soldiers who sustain major limb trauma as a result of the current conflicts in Iraq and Afghanistan. The main objective is to determine significant predictors of poor outcome following major limb trauma so that suitable modifications can be made to treatment and rehabilitation therapy. A particularly important aspect of the study looks at the outcomes of individuals who undergo limb amputation versus those who undergo extensive operative procedures to save a limb that may or may not be functional. *Performers:* Army (USAMRMC) and Johns Hopkins Bloomberg School of Public Health
- ***Military-specific Advancements in Prosthetic Limb Design and Performance—Phases 1 and 2:*** The effort seeks to improve the performance of above-the-knee prostheses by developing several key technologies that are currently unavailable in such devices. The high-power output required of the prostheses in military maneuvers such as climbing or running will be provided by a customized lightweight and compact active actuation scheme. Although power limitations traditionally barred prostheses from employing actuation, the preliminary analysis has shown great potential for energy recovery and regeneration by harnessing the cyclical nature of locomotion. *Performers:* Army (USAMRMC) and Berkeley Exoworks
- ***Miniature Generator Power for Advanced Prostheses:*** Aerodyne Research, Inc. (ARI) and Vanderbilt University are addressing the need for high-energy density power for prosthetic device by developing powered prostheses using ARI's miniature internal combustion engine (MICE) generator for the electric power source. Phase 1 will demonstrate the operation of a MICE generator at the nominal power output level required for transfemoral and transhumoral prostheses. The power requirements for transfemoral and transhumoral prostheses will be characterized, and conceptual designs for these prostheses will be developed based on a MICE generator power source. *Performers:* Army (USAMRMC), ARI, and Vanderbilt University
- ***Pilot Study to Assess the Efficacy of Mirror-box and Mental Visualization Treatments on Phantom Limb Pain:*** This pilot study focuses on the efficacy of mirror-box and mental visualization treatments on phantom limb pain. *Performer:* Army (USAMRMC and WRAMC)
- ***Prosthetic Socket Monitor and Dynamic Socket System:*** This research is developing a prosthetic socket liner that automatically and continually monitors the health of an amputee's residual limb and self-adjusts to allow better fit. The first step is to develop a liner that incorporates microelectromechanical systems equipped with pressure sensors to monitor pressure profiles in prosthetic users. Then the researchers will develop a "Dynamic Socket Liner," which

will automatically adjust to changes in pressure and residual limb volume. *Performers:* Army (USAMRMC) and Sandia National Laboratories

- ***Residual Limb Health in Response to Active Vacuum vs. Pin-lock Suction Socket Designs (Vacuum Suspension System [VASS] Study):*** This project is quantifying clinical subjective and objective benefits of a commercially available VASS compared to traditional pin-lock suction socket suspension. The study follows unilateral transtibial amputee patients for 2 years to determine the effect of the two suspension systems on limb health. *Performers:* HMJF and Army (WRAMC)
- ***"Smart" Over-ground Body-weight Support Gait Training System:*** This development project of the National Rehabilitation Hospital is prototyping key components on a new body-weight support system that will allow individuals with varying levels of walking ability to safely practice over-ground gait training. The proposed design will incorporate a dynamic unloading system that is mounted to an overhead rail system. The amount of body-weight support will be fully adjustable to accommodate individuals of various walking abilities while the rail system will incorporate extensive performance tracing features that will allow therapists to modulate training activities and track functional recovery. *Performers:* Army (USAMRMC) and National Rehabilitation Hospital
- ***Social Rehabilitation among OIF/OEF Combatants with Traumatic Amputation—An Ethnographic Study of the Experience of Rehabilitation in the Amputee Patient Care Program at Walter Reed Army Medical Center (WRAMC):*** This Phase 1 study observes and describes the experience of rehabilitative adaptations made by patients with traumatic amputation at WRAMC. In an effort to more adequately understand the process of rehabilitation, attention must be paid to the knowledge gained by patients as they move through different phases of their recovery from injury. By focusing on the knowledge gained by clinicians about patients and by patients about themselves and each other, this study explores the complex activities and negotiations that occur on the trajectory from acute injury to the resumption of the life course beyond the gates of a military medical center. *Performer:* Army (USAMRMC and WRAMC)
- ***Sports and Quality of Life Assessment in Disabled Veterans:*** Study 1. This pilot study examines individuals who use prosthetic devices who participate in organized sporting events such as the National Veterans Winter Sports Clinic (NVWSC) and the National Veterans Wheelchair Games (NVWG) and to determine how participation in these events is perceived to have impacted their life. Study 2. This study identifies personal and performance characteristics of prostheses use by military and veteran personnel with lower extremity amputations and identifies how these characteristics influence the use of prostheses versus wheelchairs. Study 3. This study examines individuals with disabilities who participate in organized sporting events such as the NVWSC and the NVWG to determine the rates and types of injuries sustained previous to and during the events and how participation in particular training programs, previous sports experience, and nutritional programs may affect injury. *Performers:* Army (USAMRMC) and Veterans Research Foundation of Pittsburgh

Face and Eye

- ***Sight Restoration by Electrical Stimulation of Visual Cortex via Arrays of Penetrating Microelectrodes:*** The objective of this effort is a proof of concept whereby the Utah microelectrode array will be demonstrated to restore limited but useful vision in nonhuman primates (NHPs) and humans. A systematic experimental approach defines the design parameters needed to implement a functional visual neural prosthesis. The team will first test the hypothesis in NHPs by using their behavioral responses to indicate what they perceive in response to patterned electrical stimulation of the cortex. They will then determine the design parameters for a functional visual neural prosthesis and study its safety and efficacy. Using the knowledge gained from the primate experimentation and additional experiments in human volunteers, they will implement a

visual neural prosthesis in profoundly blind human volunteers. They will determine if the volunteers can discriminate patterned percepts and thus, will regain functional vision from such a prosthesis. *Performers:* Army (USAMRMC) and University of Utah

Auditory

- ***Applied Research for Reducing and Reversing Noise-induced Hearing Loss:*** The goal of this program is protection of human hearing in operational environments for impulse noise. The focus is on animal testing of new pharmaceutical approaches and cochlear hair-cell regeneration strategies. *Performers:* Navy, Air Force, and Industry
- ***Development and Testing of Pharmaceuticals for Preventing and Treating Blast-induced Hearing Loss:*** This effort focuses on the development and testing of pharmaceuticals for preventing and treating blast-induced hearing loss. It addresses life-long hearing degradation for warfighters exposed to the exceptional sound levels associated with the battlefield and support operations and the long-range impact to veterans' compensation, treatment, and quality of life. *Performer:* Army (USAMRMC)
- ***Tympanic Membrane Perforation as a Biomarker of Barotrauma after Blast Exposure in Iraq: A U.S. Military Hospital Experience:*** This effort reports on the incidence of tympanic perforation in patients subject to blast exposures and describes its utility as a biomarker of more serious primary barotrauma, as observed at a U.S. military treatment facility in Iraq. *Performer:* Air Force (59th Medical Wing Wilford Hall)

Related Activities

Lastly, there were some activities that did not clearly fall within the program management category taxonomy structure. The following activities were classified as "Other":

- ***Advanced Robotic Detection of Chemical Agents, Toxic Industrial Gases, and IEDs for Force Health Protection:*** This Phase 1 SBIR project is developing a novel chemical agent sensor through a joint collaborative effort between IonFinity, the Jet Propulsion Laboratory, and Imaginative Technologies. This chemical sensor consists of a new and powerful detector called a Differential Mobility Spectrometer and a novel soft-ionization method that does not fragment or multiply-ionize the sampled species. The goal is a device that detects chemicals at low parts per billion levels after 10 seconds. Detection levels are better than those of mass spectrometry but without the need for a complicated, bulky vacuum system. *Performers:* Army (USAMRMC), IonFinity, Jet Propulsion Laboratory, and Imaginative Technologies
- ***Advanced Robotic Detection of Chemical/Biological Agents, Toxic Industrial Gases, and IEDs for Force Health Protection:*** The Energid team is developing a novel teleoperated robotic system for the rapid detection of chemical and biological agents, including toxic gases and the chemical components of IEDs. The system seamlessly integrates sampling tools and assay devices. *Performers:* Army (USAMRMC) and Energid Technologies
- ***Ballistic Protection for the Individual Warrior:*** This effort develops advanced materials technology to provide lightweight protection against fragmenting munitions and small arms threats. *Performer:* Army (RDECOM)
- ***Development of the Critical Care Air Transport Nurse Deployability Index (CCATT-DI):*** This index is a self-report instrument to measure deployment preparedness in a unique population of military nurses. Such an instrument has potential for use as a screening tool to identify pre-deployment refresher training needs of current CCATT nurses as a pre-test/post-test method of evaluating the effectiveness of CCATT training programs, as a potential predictor of the success of CCATT missions, or as a post-deployment checklist for after-action reports. *Performer:* Air Force (59th Medical Wing Wilford Hall)

- ***IED Armor Development:*** This project develops add-on IED armor kits. *Performers:* Army (USAARL), General Dynamics Land Systems, BAE System, Inc., and DoD (Joint Improvised Explosive Device Defeat Organization [JIEDDO])
- ***Mosaic Flexible Body Armor:*** This effort supports the development of a small arms protective armor system that is flexible. *Performer:* Army (RDECOM) and Warwick Mills
- ***NCDR—Field Medical Robotics for Military Combat Casualty Care:*** The program's goal is to acquire/develop, integrate, and test a general purpose robotic arm that has multiple degrees of freedom (4–6+). The arm must be of suitable scale, weight, performance, and cost to be integrated onto the unmanned version of the Segway RMP-400 commonly known as Jaguar. The arm must minimally provide acceptable accuracy, capacity, and dexterity for positioning the chemical, biological, explosive (CBE) detector, as well as provide either a built-in end effector suitable for use with the CBE payload, or a general purpose end effector that can handle multiple payloads. A generic mechanical interface system whereby the Vecna Battlefield Extraction and Retrieval robot may be integrated with the TAGS-CX will be designed and demonstrated. *Performers:* Army (USAMRMC) and National Center for Defense Robotics
- ***Next-generation Bomb Suit (NGBS):*** The proposed NGBS combines state-of-the-art materials, incorporates innovative protection concepts, and integrates a comprehensive array of sensors to provide adequate protection for Explosive Ordnance Disposal technicians performing the dangerous and difficult task of finding, inspecting, and disabling unexploded ordnance and IEDs. The NGBS will also include a self-contained breathing apparatus and cooling and hydration systems. The first phase of effort performed an evaluation of technologies required to develop the NGBS and performed the conceptual design. *Performer:* DoD (TSWG)
- ***Raman Bio Identification (RBI) Robot:*** ChemImage and Applied Perception are developing a limited degree-of-freedom positioning system to place a CBE detector near objects to be analyzed for hazards. This positioning system will be specifically targeted for operation with the CBE detector and likely not suitable for more general use for other potential missions. *Performers:* Army (USAMRMC), ChemImage Corporation, and Applied Perception Inc.
- ***Supplemental Body Armor:*** This effort supports advanced materials research for personnel armor. *Performer:* Army (RDECOM)
- ***Self-Sintered Ceramic Materials:*** This effort supports the development of an improved ceramic material for personnel armor. *Performers:* Army (RDECOM) and Morgan AM&T
- ***Thermal Stress and Human Responses Associated with Litter Position on the C-141 Starlifter and C-17 Globemaster III:*** Describes the thermal environment of ten different areas commonly used for patient care in the cargo compartment of C-141B "Starlifter" aircraft and C-17 "Globemaster III" when they are configured for aeromedical transport. *Performer:* Air Force (59th Medical Wing Wilford Hall, Air Mobility Command, and Air Force)

CHAPTER 3

Requirement: A consolidated budget presentation for Department of Defense biomedical research efforts and studies related to blast injury for the 2 fiscal years following the year of the report.

Table 3-1 shows the consolidated fiscal budget for funded DoD biomedical research efforts and studies related to blast injury for FY07 through FY09 by program management category. These fiscal values are consistent with the planning, programming, and budgeting guidance of the Department and reflect efforts included in the Program Objective Memorandum.

Table 3-1. Identified Funding by Fiscal Year by Program Management Category

Program Management Category	FY07* ($K)	FY08 ($K)	FY09 ($K)	Grand Total ($K)
Surveillance	1,382	0	0	1,382
Traumatic Brain Injury	13,747	11,767	12,389	37,903
Other Tissues & Organs	38,830	47,884	64,269	150,983
Modeling, Simulation, Test, and Evaluation	14,064	10,714	11,079	35,857
Extremity	42,993	2,505	2,423	47,921
Face & Eye	1,694	1,960	2,706	6,360
Auditory	258	0	0	258
Grand Total	112,968	74,830	92,866	280,664

* FY07 includes current Congressional Special Interest and SBIR Program funding appropriated.

CHAPTER 4

Requirement: A description of any gaps in the capabilities of the Department and any plans to address such gaps within biomedical research related to blast injury, blast injury diagnostic and treatment programs, and blast injury tracking and monitoring activities.

Consistent with the provisions of the DoD EA, USAMRMC sponsored a DoD Blast Injury Research Planning Meeting in Frederick, Maryland on July 10, 2006. The meeting and subsequent proceedings delineated the future directions of blast injury research by identifying where gaps in the capabilities of the Department exist and assisted in plans to address such gaps. Identifying critical knowledge gaps enable scientists to develop and prioritize their approach to remedy shortfalls in scientific understanding (see **Table 4-1**).

Table 4-1. Gaps in Capabilities (√) by Functional Area

Program Management Category	Protection	Diagnostics	Treatment	Rehabilitation
Surveillance	√			
Traumatic Brain Injury	√	√		
Other Tissues and Organs	√		√	√
Modeling, Simulation, Test, and Evaluation	√			
Extremity				√
Face and Eye			√	
Auditory			√	√

The following is a description of the gaps in the capabilities of the Department by the functional areas of protection, diagnostics, treatment, and rehabilitation for each program management category:

Surveillance

- ***Protection***
  - *Incident and Injury Linkages:* Analyze the effect of blast on body armor and subsequent injury.
  - *Data Collection:* Collect more detailed incident and injury data, including more detailed autopsy data.
  - *Databases:* Develop robust epidemiological databases; standardize data definitions prior to merging of data.
  - *Individual Differences:* Determine the effects of age, gender, and size on PPE performance.
  - *Neck Injuries:* Determine the incidence of neck injuries and develop protection strategies.

Traumatic Brain Injury

- ***Protection***
  - *Models:* Standardize and validate surrogate test models and nomenclature; develop a brain injury model; develop injury criteria.
  - *TBI Effects:* Determine whether there is a TBI associated with primary blast.
  - *Case Identification Methods:* Develop a better means of identifying cases of blast injury, especially those with milder injuries.
  - *Neuroprotectants:* Develop better neuroprotectants for acute head injuries ranging from severe penetrating injuries to mTBI and develop solutions to decompressive craniotomy.

- ***Diagnostics***
  - *Improved Clinical Data for Mild Injuries:* Develop and gain approval for field screening test(s) sensitive to mTBI and vet through a nationally recognized panel; collect better clinical data on which to base a specific diagnosis of blast, PTSD, or other type of injury; develop a means to predict chronic injuries before they occur; determine the extent of subtle head injuries; and conduct basic research to determine whether BOP can cause mTBI.
  - *Dosimeters to Record Biodynamic Forces Acting on the Head:* Develop a dosimeter that can be worn in the combat helmet to measure and record the forces acting on the head during a blast exposure.
  - *Expand the Use of Biomarkers and Study Effects of Multiple Concussions:* Identify biomarker(s) of TBI that can distinguish mTBI from PTSD-like symptoms; develop a diagnostic tool, perhaps biomarkers that can predict the effects of multiple concussions; and identify biomarkers that can be used as prognostic indicators of lung/internal organ damage.

Other Tissues and Organs

- ***Protection***
  - *Primary and Synergistic Effects:* Determine the synergistic effects of primary and secondary blast injuries on tissue response and wound healing.
  - *Repeat Exposures:* Determine the effects of repeated blast exposures on areas besides the brain.
  - *High-rate Material Properties of Animal and Human Tissue:* Determine how animal and human tissues respond to stresses caused by high-rate events like blast to develop high-rate tissue properties for improved blast injury prediction models.
- ***Treatment***
  - *Clinical Practice Guidelines:* Conduct translational research validation for field clinical practice guidelines, especially for actions taken during the "platinum 10 minutes," and vet through expert nationally recognized panel.
  - *Animal Models:* Develop a better crosswalk between animal models and human treatment studies and study mechanical effects at the moment of impact and the molecular pathways behind the response to the impact.
  - *Freeze Dried Human Plasma:* Develop better methods of getting freeze-dried human plasma to the medic on the battlefield.
- ***Rehabilitation***
  - *Limbs:* Explore new technologies in tissue regeneration as a possible means of repairing injured limbs and replacing lost limbs.

Modeling, Simulation, Test, and Evaluation

- ***Protection***
  - *Environmental Injury Models:* Model the effects of inhaled toxic gases, including smoke and aerosols, associated with blast events.

Extremity

- ***Rehabilitation***
  - *Therapy:* Conduct more physical and occupational therapy research.

Face and Eye

- ***Treatment***
  - *Facial Injuries:* Develop acute treatments of facial and eye injuries to mitigate damage and enhance repair (a better means of treating facial injuries is needed, as there are social implications) and consider how acute treatment affects longer-term reconstruction of the face and follow-on cosmetic surgery.

Auditory

- ***Treatment***
  - *Drugs to Treat Hearing Loss:* Accelerate research on drugs to treat noise-induced hearing loss and to regenerate cochlea hairs.
- ***Rehabilitation***
  - *Hearing Loss Studies with the National Institutes of Health (NIH):* Coordinate with other agencies, especially NIH agencies, for cochlear hair cell protection and repair and acute protection/restoration of hearing following impulse noise exposure.
  - *Auditory Injury:* A longitudinal study on hearing loss in conjunction with the VA; determine whether there is a correlation between hearing loss and cognitive performance decrements; improve screening of troops for hearing losses; and ensure collaboration between parallel service efforts on hearing loss.

The identification of gaps in capabilities enabled the Department to align and develop a portfolio of biomedical research efforts necessary to address gaps in the functional areas of protection, diagnostics, treatment, and rehabilitation for each program management category (see **Table 4-2**).

Table 4-2. Portfolio of Biomedical Research Efforts (√) Necessary to Address Gaps* in Capabilities by Program Management Categories

Program Management Category	Protection	Diagnostics	Treatment	Rehabilitation
Surveillance	√	√	√	√
Traumatic Brain Injury	√	√	√	√
Other Tissues and Organs	√	√	√	√
Modeling, Simulation, Test and Evaluation	√			
Extremity			√	√
Face and Eye	√		√	
Auditory	√		√	√

* Shaded boxes reflect areas of identified gaps in capabilities from Table 4-1.

The portfolio of proposed biomedical research efforts includes the following:

Surveillance

- ***Protection***
  - Develop and integrate medical and nonmedical databases containing injury, event, and forensic data. Perform studies and analyses of the relationships between blast, PPE, vehicles and injuries to inform development of better warfighter protection systems and medical response to injuries (informs diagnostics, treatment, and rehabilitation).
  - Meet medical and nonmedical needs for biomedically valid analysis through development of data integration tools and models.
  - Implement a standardized operational data reporting system for IED incidents and vehicle damage for integration with injury data.

- Implement a PPE collection and failure analysis data reporting system for integration with injury data.

Traumatic Brain Injury

- ***Protection***
  - Identify and develop new neuroprotective strategies, to include pharmaceuticals, to mitigate the effects of TBI.
  - Determine whether there is a TBI associated with primary blast.
- ***Diagnostics***
  - Identify and develop new diagnostics to mitigate the effects of TBI.
    - Develop and gain approval for field screening test(s) sensitive to mTBI.
    - Expand capability for greater specificity with biomarker(s) of TBI (e.g., that distinguishes mTBI from PTSD-like symptoms).
- ***Treatment***
  - Conduct research, development, test, and evaluation to identify and develop new treatments to mitigate the effects of TBI.
    - Develop better neuroprotective treatments for acute head injury, from severe penetrating injuries to mTBI, including solutions to decompressive craniotomy.
  - Sustain the DVBIC program core functions (e.g., coordination of care, record tracking, surveillance and outcomes studies, treatment assistance, and education and training).
- ***Rehabilitation***
  - Develop approaches to improve longer-term outcomes in TBI, to include concussive brain injury.
  - Develop criteria for withdrawal from duty for recovery and return to duty after concussive head injury/exposure.
  - Increase levels of care for severe TBI neurosurgical cases during evacuation and at the Washington Area Neurosurgical Consortium.

Other Tissues and Organs

- ***Diagnostics***
  - Develop diagnostics for wound infection.
  - Develop diagnostic systems and prognostics for blast-related injury.
    - Enhance biomarker indicators for prognostic indicators of lung/internal organ damage.
- ***Treatment***
  - Conduct translational research validation for field clinical practice guidelines, especially for actions in the “platinum 10 minutes.”
  - Develop advanced medical strategies for resuscitation.
  - Develop advanced medical treatments for wound infection.
  - Develop new capabilities for rapid wound healing and tissue regeneration.
  - Develop enhanced capabilities in Damage Control Resuscitation to include advanced development of an individual oxygen generator, blood products with enhanced storage characteristics, and improved far-forward availability of blood, platelets, and plasma.

- ***Rehabilitation***
  - Advance tissue regeneration methods, limb prosthetics, other prostheses, and repair/restoration of facial and inner ear injury.

Modeling, Simulation, Test, and Evaluation

- ***Protection***
  - Validate health risk criteria and improve health risk assessment tools.
  - Develop sensor systems to provide blast effects data required for modeling and simulation of blast-related injury.
  - Develop integrated predictive models of combined blast effects (primary, secondary, tertiary, and quaternary).

Extremity

- ***Treatment***
  - Develop prosthetic and biomedical assistive technologies for disabled extremities.
  - Develop novel technologies to regenerate bone and joints.
- ***Rehabilitation***
  - Develop advanced prosthetics and biomedical assistive technologies for disabled extremities.
  - Develop testbed sites for development of advanced prosthetics.

Face and Eye

- ***Protection***
  - Evaluate neuroprotectant drugs and biologics for mitigation of retinal injury after trauma.
- ***Treatment***
  - Develop new methods for skull and facial reconstruction.
  - Develop clinical guidelines for improved medical management of ocular and facial injury in field and tertiary care settings.

Auditory

- ***Protection***
  - Evaluate candidate systems for enhanced hearing protection
- ***Treatment***
  - Identify and complete development of novel drugs to prevent noise-induced hearing loss.
- ***Rehabilitation***
  - Identify and complete development of novel drugs to mitigate noise-induced hearing loss.

CHAPTER 5

Requirement: A description of collaboration, if any, with other departments and agencies of the federal government, and with other countries, during the 2 years preceding the report in efforts for the prevention, mitigation, and treatment of blast injuries.

The prevention, mitigation, and treatment of blast injuries necessitate a multidisciplinary approach best achieved by scientific teaming through collaboration. Collaboration can act to optimize the scientific growth and productivity of the Department's efforts in this area. A description of collaborative efforts with other departments and agencies of the federal government, and with other countries, during the 2 years preceding the report in efforts for the prevention, mitigation, and treatment of blast injuries follows.

Surveillance

- ***Recruitment Protocol for Blast and Nonblast Patients:*** This study's primary goal is research of post-deployment mental illness. The study is recruiting and characterizing subjects for a database from which to draw subjects for future studies to look at three principal aims: (1) to determine whether early intervention in post-deployment mental health is effective in forestalling the development or decreasing the severity of post-deployment mental illness, (2) to determine what neuroimaging, neurocognitive, or other characteristics predict the development of post-deployment mental illness, and (3) to assess the longitudinal course of post-deployment mental illness. The study is taking place at WRAMC and VA VISIN 6. *Performers:* Army (WRAMC) and VA

Traumatic Brain Injury (Note: The DVBIC and its collaborative network partners in the MHS and VA serve as the primary testbeds for translational research for mild to moderate TBI.)

- ***A Randomized Placebo-controlled Trial of Citalopram for Anxiety Disorders Following TBI:*** This effort studies the effects of citalopram, a serotonin reuptake inhibitor, for the treatment of anxiety experienced by individuals after TBI. This project seeks to treat individuals who meet criteria for DSM-IV diagnosis of Anxiety Disorder Due to a General Medical Condition TBI within 6 to 14 months of injury. *Performers:* DoD (DVBIC) and Air Force (59th Medical Wing Wilford Hall)
- ***A Randomized Placebo-controlled Trial of Sertraline for the Neurobehavioral Sequelae of TBI at DVBIC Military Sites:*** This study examines the effectiveness of Sertraline in treating post-TBI neurobehavioral systems of irritability, depression, frustration, anxiety, and other elements of the post-concussive syndrome. Patients with blast-related TBIs are compared to patients with other TBIs to determine relative treatment effectiveness in these two populations. *Performer:* DoD (DVBIC)
- ***Community Re-entry for Blast-injured Fighters at Virginia NeuroCare and Laurel Highlands Rehabilitation Center:*** This program provides active-duty blast patients with community re-entry, transitional living, and vocational and outpatient neuro-rehabilitation services. *Performer:* DoD (DVBIC)
- ***Defense and Veterans Brain Injury Center (DVBIC) Core Evaluation Protocol:*** This multidisciplinary evaluation battery provides detailed, standardized assessments of patients with TBI treated in the seven lead DVBIC centers. The assessments are initiated and used by clinicians to provide information to plan treatments for patients. Approximately 250 soldiers injured in OIF/OEF and evacuated for care at WRAMC have received core protocol evaluations under this treatment protocol. The results provide initial evidence on the effects of blast-related versus nonblast-related TBIs. *Performer:* DoD (DVBIC)

- ***DVBIC Prospective and Retrospective TBI Clinical Tracking Protocol:*** The purpose of this study is to ensure that all military (DoD) and VA TBI patients receive TBI-specific evaluation and follow-up by creating a database of clinical data obtained during standard TBI evaluation. These data are analyzed in a descriptive, observational study and describe the clinical characteristics of TBIs occurring in theater, as well as the correlative etiology of the TBI with demographics, injury severity, associated injuries, symptomatology, and outcomes (e.g., return to duty and work). The TBI patient population has grown exponentially and becomes more complex in recent years because of the serious and multi-system trauma received in current conflicts. This study collects information about symptoms and recovery after TBI that will allow comparison of the effectiveness and cost of various TBI treatment and rehabilitation strategies and help determine what is the best care for individuals who have experienced a TBI. *Performers:* DoD (DVBIC) and HMJF
- ***DVBIC Randomized Controlled Trial (RCT)—The Effectiveness of Methylphenidate:*** This program is: (1) determining Class 1 evidence on the effectiveness of methylphenidate during acute rehabilitation in improving outcome after moderate to severe TBI; (2) completing follow-up evaluation, analyzing data, and generating findings for the current DVBIC RCT that investigates the efficacy of a didactic cognitive treatment program versus a neuro-functional treatment program; and (3) conducting single-center pilot studies that test innovative approaches for the assessment and treatment of TBI patients. *Performer:* DoD (DVBIC)
- ***Defense and Veterans Head Injury Program: Effects of Gradual Return to Work Following Mild Closed Head Injuries:*** This effort compares two different approaches to returning to work after an mTBI. One approach involves 2 weeks' convalescent leave followed by 1 week of limited duty. The second approach is 3 weeks of limited duty. Both approaches are under a physician's orders to avoid activities that are mentally, emotionally, or physically demanding. *Performers:* Air Force (59th Medical Wing Wilford Hall) and DoD (DVBIC)
- ***Enhanced Neurorehabilitation for TBI:*** This effort develops TBI rehabilitation for OIF veterans using non-pharmaceutical alterations in environment. *Performers:* Air Force (HQ USAF/Surgeon General), DoD (DVBIC), Wright State University, University of Ottowa and Carlton University, Canada
- ***Mental Health Research, Education, and Clinical Center (MIRECC) Neurocognitive Protocol for Blast and Nonblast Patients:*** This study investigates post-deployment PTSD and TBI in recently discharged veterans, active-duty military and returning National Guard personnel to discriminate between the two separate disorders and specify their degree of co-morbid occurrence. It also examines the longitudinal course and outcome, with a particular interest in the effect of change in one disorder on the presentation of the other and in isolating variables that predict therapeutic improvement. *Performer:* DoD (DVBIC)
- ***Mental Illness Research, Education and Clinical Center (MIRECC) Recruitment Protocol for Blast and Nonblast Patients:*** This study is recruiting and characterizing subjects for a database from which to draw subjects for future studies to look at three principal aims: (1) to determine whether early intervention in post-deployment mental health is effective in forestalling the development or decreasing the severity of post-deployment mental illness, (2) to determine what neuroimaging, neurocognitive, or other characteristics predict the development of post-deployment mental illness, and (3) to assess the longitudinal course of post-deployment mental illness. *Performer:* DoD (DVBIC)
- ***Military Blast-related Traumatic Brain Injury—A Study of Neuroanatomical and Neurobehavioral Sequelae and Low-cost Clinical Intervention:*** This study is: (1) developing prevalence estimates for sequelae (neuroanatomical and neurobehavioral) of blast-related TBI in a military population; and (2) testing the efficacy of a low-cost telephonic clinical intervention.

Comparisons are made between blast/nonblast-related TBIs and treated/nontreated groups. *Performer:* DoD (DVBIC)

- ***Pilot Study: Incidence and Characteristics of Post-traumatic Stress Disorder Following Traumatic Brain Injury:*** This effort focuses on TBI within a combat environment on the theory that combat presents some unique stressors not encountered in other situations. This is a two-part study, the first being a retrospective analysis of the incidence and severity of PTSD symptoms in a large sample of DVBIC TBI patients. The second part is a prospective analysis of PTSD in returning military service members who received a TBI while deployed to OIF or OEF. *Performers:* Air Force (59th Medical Wing Wilford Hall) and DoD (DVBIC)
- ***Traumatic Brain Injury and Outcomes:*** This study characterizes TBIs among military personnel during the second phase of OIF from early in the medical chain of evacuation through Landstuhl Regional Medical Center. Data come from the Navy–Marine Corps CTR and includes both battle and nonbattle injuries. Follow-up of TBI patients is conducted to examine the short-term medical and personnel-related effects of TBI among those surviving. *Performer:* DoD (DVBIC)

Other Tissues and Organs

- ***Advanced Resuscitation Fluid:*** This effort focuses on the advanced clinical development of resuscitation fluids. *Performers:* Army (USAMRMC); NHLBI; Institutes of Health Research, Canada; and DRDC, Canada
- ***CRF Spinal Cord Injury Clinical Trials Research Initiative:*** The CRF proposes conducting clinical trials in a joint effort with military hospitals, VA hospitals, and NACTN. Rapid translation of network-tested SCI therapies will reach first responders and the bedside sooner, resulting in improved functional recovery of more individuals. The Principal Investigator (PI) proposes to collaborate with VA and military medical centers to perform more relevant, clinically significant assessment of the management and course of SCI. The PI cites many examples of promising therapies that have not been conclusively demonstrated to improve outcomes and believes that this large network would enable improved, standardized assessment. *Performers:* Army (USAMRMC), CRF, NACTN, and VA
- ***Damage Control Resuscitation: Clinical Trial on Hypertonic Saline Dextran:*** This effort studied the individual and combined effects of existing and novel replacement fluids and artificial blood products to treat for shock and attendant multi-organ failure. The Resuscitation Outcomes Consortium, in collaboration with the NHLBI, opened enrollment for a clinical trial on Hypertonic Saline Dextran as a replacement fluid for trauma victims and developed plans for a trial of the Impedance Threshold Device. *Performers:* Army (USAMRMC), NHLBI, and Canadian Defense Forces
- ***Damage Control Resuscitation: Collaboration on Resuscitation and Hemorrhage Control:*** This project combines previous program areas of hemorrhage control, blood products, and resuscitation and provides an integrated approach to treatment of severely wounded casualties. The individual and combined effects of existing and novel replacement fluids and artificial blood products to treat for shock and attendant multi-organ failure are studied. This includes the NHLBI collaboration on resuscitation and hemorrhage control. *Performers:* Army, NHLBI, and Canadian Defense Forces
- ***Damage Control Resuscitation: Studies of Hemostatic Dressings and Drugs:*** This project provides an integrated approach to treatment of severely wounded casualties and includes studies of hemostatic dressings and drugs, including recombinant Factor VIIa (rFVIIa) in animal models of hemorrhage without or with a concomitant coagulopathy. The studies resulted in the fielding of the

Chitosan hemostatic dressing, the Combat Applications Tourniquet, and the in theater use of rFVIIa as an aid to clotting. *Performers:* Army (USAMRMC), NHLBI, and Canadian Defense Forces

- ***Individual Protection against Novel Blast Threats:*** This effort focuses on development of BOP protection from primary blast lung injury to be used in conjunction with current and future body armor systems. *Performers:* Army (USAMRMC), Navy (Naval Surface Warfare Center – Indian Head), Army Research Laboratory, Canada, Australia, and UK under TTCP Project Arrangement
- ***National Heart, Lung, and Blood Institute Collaboration—Resuscitation Outcomes Consortium:*** This effort focuses on the application for IND status for a candidate resuscitation fluid(s) or drugs and to conduct early clinical studies of candidate fluids, drugs, and/or biological agents for treatment of fluid loss in battlefield casualties. *Performers:* Army and NHLBI, and a consortium of 11 clinical trial centers including 2 in Canada
- ***NATO Task Group on Behind Armor Blunt Trauma (BABT) (KTA 1-38):*** The BABT Task Group's purpose is to define the problem of blunt trauma behind body armor, including head trauma, and to propose testing methods for body armor developers. *Performers:* DRDC-Valcartier; DSTL, United Kingdom; Army (Natick Soldier Center); and National Institute of Standards and Technology

Modeling, Simulation, Test and Evaluation

- ***Blast Protection for the Individual Warfighter (The Technical Cooperation Program, Project Arrangement No. PA-1/05/WPN):*** The USAMRMC is working with defense organizations from the United States, United Kingdom, Canada, and Australia to develop and demonstrate an integrated system that will protect the individual Warfighter from ballistic and blast threats, including blast from thermobaric weapons. The four nations are performing this work under the auspices of TTCP in a 5-year PA. The USAMRMC brings a wealth of blast bioeffects knowledge and several unique tools to bear on this challenging task. These biomedically based tools include a blast injury prediction model, known as "INJURY," and a behind body armor blunt trauma injury prediction model and testing device. The Military Operational Medical Research Program also has an extensive blast injury bioeffects database containing data from nearly 50 years of blast bioeffects research. The PA will enable the four nations to exchange information and equipment and to participate in joint tests. *Performers:* DSTL, United Kingdom; DRDC-Valcartier; Army (Natick Soldier Center); and Defense Science & Technology Organization, Australia
- ***US–UK Information Exchange Agreement (IEA) on Novel Explosives (NE):*** This IEA was established between DTRA and DSTL as a vehicle for exchanging information (up to the Secret level) on NE development and survivability. USAMRMC is a participating organization in this IEA. A primary focus is to share information on blast injury prediction models to develop effective Warfighter protection systems. *Performers:* DTRA, DSTL, United Kingdom, and Army (Natick Soldier Center)
- ***USAMRMC and National Highway Traffic Safety Administration (NHTSA) Collaborative Agreement on Blunt Trauma Injury Models:*** The USAMRMC and NHTSA are interested in developing biomedically valid blunt trauma injury prediction tools. The USAMRMC's focus is on developing tools to guide the development of effective soldier protection systems, like body armor. The NHTSA focus is on developing vehicle crash safety standards. The underlying human injury prediction models are the same. Under this collaborative agreement, the organizations share information and leverage each others research efforts to develop valid blunt trauma injury tools. *Performers:* Army (USAMRMC), NHTSA, L-3 Communications/Jaycor

CHAPTER 6

Requirement: A description of any efforts during the 2 years preceding the report to disseminate findings on the diagnosis and treatment of blast injuries through civilian and military research and medical communities.

The efforts during the previous 2 years to disseminate findings on the diagnosis and treatment of blast injuries through civilian and military research and medical communities have been organized into presentations, publications, and technical reports. **Table 6-1** shows the number of presentations, publications, and technical reports by program management category.

Table 6-1. Number of Presentations, Publications, and Technical Reports by Program Management Category

Program Management Category	Presentations	Publications	Technical Reports
Surveillance	54	6	3
Traumatic Brain Injury	118	19	12
Other Tissues & Organs	171	183	57
Modeling, Simulation, Test, and Evaluation	42	11	32
Extremity	57	16	40
Face & Eye	3	2	5
Auditory	29	0	0
Other	7	1	2
Total Presentations	481	238	151

CHAPTER 7

Requirement: A description of the status of efforts during the 2 years preceding the report to incorporate blast injury effects data into appropriate programs of the Department of Defense and into the development of comprehensive force protection systems that are effective in confronting blast, ballistic, and fire threats.

The following are the *Statuses* of efforts during the previous 2 years to incorporate blast injury effects data into various programs of the DoD and into the development of comprehensive force protection systems that are effective in confronting blast, ballistic, and fire threats:

Traumatic Brain Injury

- Guidelines for Blunt Head Injury Protection: To improve the blunt head injury protection of the standard ballistic troop helmet
  - *Status:* Completed. Design guidelines for energy absorbing pads (providing a 35% improvement) were incorporated into the Advanced Combat Helmet (ACH)
  - *End User:* Program Manager, Soldier Equipment—Advanced Combat Helmet
- Tissue-Level Mechanisms of Primary Blast Injury: To identify fundamental mechanisms of blast injury to the brain (TBI)
  - *Status:* Continuing.
  - *End Users:* U.S. Army Program Manager Soldier Equipment and U.S. Marine Corps Soldier Systems Command, U.S. Army Medical Command
- Guidelines for the field management of combat-related head trauma
  - *Status:* Completed. Incorporated Army-wide and in the field
  - *End Users:* Medics, Physician Assistants, Nurse Practitioners, and Physicians
- Military Acute Concussion Evaluation (MACE)
  - *Status:* Completed. Incorporated Army-wide and in the field
  - *End Users:* Medics, Physician Assistants, Nurse Practitioners, and Physicians
- TBI Screenings—Screening and treatment of military fighters with TBIs at Ft. Carson, CO; Ft. Bragg, NC; and Camp Pendleton, CA
  - *Status:* Continuing.
  - *End Users:* MHS and service members
- TBI Diagnostic and Treatment Training: San Diego Naval Medical Center DVBIC Site-training
  - *Status:* Continuing. Provided by the PI as requested
  - *End Users:* Physician Assistants, Nurse Practitioners, and Physicians
- TBI Diagnostic and Treatment Training: Elmendorf AFB, and Fairbanks, AK
  - *Status:* TBI diagnostic and treatment training was provided to military practitioners
  - *End User:* Senior Military Staff
- Advanced Research in Technologies for Protecting Warfighters from Blast Induced Brain Injury. Blast Induced TBI: Modeling the Physical and Cognitive Effects of Enhanced Blast Exposure

  - *Status:* Continuing. The results and data are being shared through journal publications, various DoD working groups on blast injury, and through review meetings and conferences with Army counterparts conducting blast research.
  - *End Users:* Natick Soldier Systems Center and MHS
- "Survive, Thrive, Alive!" Documentary: Features current military fighters telling their stories of living with TBIs
  - *Status:* Currently airing on the Pentagon Channel and 5,000 copies are being disseminated to the civilian community and military-wide.
  - *End Users:* General public and the military community

Other Tissues and Organs

- Damage Control Resuscitation: Bleeding Control Using Recombinant Factor VIIa:
  - *Status:* Continuing. Animal studies have show that Recombinant Factor VIIa can prolong the life of severely bleeding animals for hours and offer hope that this will also be the case for humans.
  - *End User:* MHS
- Damage Control Resuscitation: Compressible hemorrhage
  - *Status:* Continuing. The Chitosan bandage and the CAT, both used to control extremity hemorrhage, have been incorporated into the Individual First Aid Kit issued to every soldier.
  - *End Users:* Land Warrior and MHS
- Damage Control Resuscitation: Reform Current Resuscitation Practices for Combat Wounds to Compensate for Reduced Blood Clotting Ability in the Most Severely Injured Patients: Continuing
  - *Status:* Continuing. Current practices in theater have been changed to measure clotting ability of the wounded patient's blood upon admission to the hospital and administer clotting agents if their clotting ability is impaired.
  - *End User:* MHS
- Damage Control Resuscitation: Tactical Combat Casualty Care (TCCC) – Tailoring First Responder Treatment to the Constraints of the Modern Battlefield: Completed
  - *Status:* Published new TCCC guidelines that were subsequently approved by the American College of Surgeons and incorporated as Chapter 16 of the Civilian Pre-Hospital Trauma Life Support manual.
  - *End Users:* MHS and civilian first responders

Modeling, Simulation, Test, and Evaluation

- Body Armor Blunt Trauma Assessment: A Biomedically Based Method for Testing Performance of Lightweight Body Armor:
  - *Status:* Completed
  - *End User:* U.S. Army Natick Soldier Systems Center
- Assessment of Blast Injury from ejection seat explosives in the Joint Strike Fighter (JSF) cockpit: Continuing
  - *Status:* Ongoing. The USAMRMC collected data from JSF ejection seat tests and analyzed the data with the INJURY (USAMRMC's blast lung injury prediction tool) model.

  - *End User:* Joint Strike Fighter Program

- Evaluation and Clearance of Medical Devices for Medevac
  - *Status:* Continuing. Over 40 medical devices have been tested and cleared for compatibility with the aviation medical evacuation environment, including all Patient Movement Items. Recent notable successes include the peripheral pain pump and ICP monitors that were urgent priorities for immediate use in evacuating warfighters wounded in OIF/OEF.
  - *End Users:* USAMRMC medical system program managers.
- Surface Wound Mapping: Pictorial/graphical compilation of wounds and severity levels highlighting opportunities for improved protection
  - *Status:* Continuing. Being considered for use in the JTAPIC Program
  - *End Users:* U.S. Army Program Manager Soldier Equipment, U.S. Marine Corps Soldier System Command, and USAMRMC
- IED Shrapnel and Blast Characterization: to determine the injury environment to the human in IED events by providing realistic fragment and BOP information from roadside artillery shell IEDs in current operations.
  - *Status:* Ongoing
  - *End Users:* Joint Service lethality and ballistic models
- Extremity Body Armor: Evaluate human factors, mission impact, and ballistic performance of multiple variants of extremity body armor
  - *Status:* U.S. Marine Corps has adopted one variant and has pursued multiple product improvements.
  - *End Users:* U.S. Marine Corps and U.S. Army PM Soldier Equipment
- Evaluation of Commercial Off the Shelf (COTS) cooling devices—ReflecTec Ballistic Vest Thermal Inserts and Helmet Liner Thermal Inserts
  - *Status:* Completed. U.S. Army Research Institute of Environmental Medicine concluded that adding these products to the Individual Body Armor and Kevlar helmet did not reduce physiological or perceptual strain in hot environments with either high or low radiant heat load.
  - *End User:* Chief of Staff of the Army
- Advanced Combat Helmet Task Force Study: To examine the pros and cons of the new ACH ballistic helmet compared to the issued Protective Armor System Ground Troops protective helmet.
  - *Status:* Completed. USAARL identified patterns of improper wear and potential vulnerability that triggered Army-wide improvements in training and helmet-fitting procedures.
  - *End User:* Army ACH program

Face and Eye

- Guidelines for Face Protection for Combat Vehicle Drivers: due to windscreen fragments secondary to explosions (IEDs, shrapnel).
  - *Status:* Completed. USAARL recommended a combination of COTS technologies to address the immediate problem.
  - *End Users:* U.S. Army Transportation School and U.S. Army Natick Soldier Systems Center

A description follows of efforts during the 2 years preceding the report to incorporate blast injury effects data into appropriate programs of the DoD and into the development of comprehensive force protection

systems that are effective in confronting blast, ballistic, and fire threats through largely health and health care policy instruments to the field, notably All Army Activities (ALARACT) notifications by each program management category.

Surveillance

- Memorandum of Agreement between the United States Army Surgeon General and the Commander, Multi-National Corps, Iraq, 29 November 2005. Clarified and modified existing policies and procedures for the conduct of human subjects research in the Multi National Corps, Iraq (MNC-I) Area of Operations (AO) and clarified procedures and responsibilities for scientific review and human subjects protections review, approval, and compliance oversight for all research conducted in the MNC-I AO.

Traumatic Brain Injury

- ALARACT, Department of the Army (DA), Office of the Surgeon General, Subject: Concussion in Soldiers in the Battlefield, 17 July 2006. Alerted commanders and leaders to the signs and symptoms of concussions and its impact on the combat effectiveness of soldiers. It recommended that soldiers with suspected concussions should be referred for medical evaluation by echelon 2 medical personnel, as the tactical situation permitted.
- A Clinical Practice Guideline for TBI and MACE was developed and posted to the Joint Patient Tracking Application website.

Other Tissues and Organs

- Memorandum, DA, 44th U.S. Army Medical Command, XVIIIth Airborne Corps, Subject: OIF Medical Services—Antithrombotic Therapy for the Prevention and Treatment of Thrombosis, 25 December 2004. Establishes guidelines for antithrombotic therapy for the prevention and treatment of thrombosis.
- ALARACT, DA, Office of the Surgeon General, Subject: Availability of the CAT and SOFTT Individual Soldier Tourniquet (IST) for Deploying Soldiers, 26 March 2005. Authorized issue of CAT or SOFTT IST for soldiers deploying to the CENTCOM AOR.
- ALARACT, DA, Office of the Surgeon General, Subject: Individual Soldier Tourniquets – Combat Application Tourniquets (CAT), 28 March 2005. Approved selection of the CAT for fielding with the Individual First Aid Kit (IFAK) and of the Special Operations Forces Tactical Tourniquet (SOFTT).
- ALARACT, DA, Office of the Surgeon General, Subject: Availability of the CAT and SOFTT Individual Soldier Tourniquets (IST) for Deploying Soldiers, 21 April 2005. Directs soldiers deploying to CENTCOM AOR to carry either the CAT or SOFTT.
- ALARACT, DA, Office of the Surgeon General, Subject: Individual Soldier Hemostatic Dressing, 15 September 2005. Approval of the Chitosan dressing to be carried by each soldier, combat lifesaver, and combat medic deployed to CENTCOM.
- ALARACT, DA, Office of the Surgeon General, Subject: High Incidence of Hand Burns, 22 December 2005. Alerted commanders to the disproportionate number of hand burns that soldiers in OIF/OEF were experiencing in relation to other body parts and recommended the wearing of fire resistant Nomex or Kevlar gloves, particularly during high-risk.
- Memorandum, Office of the Assistant Secretary of Defense, Subject: Defense-wide Policy on Combat Trauma Casualty Hypothermia Prevention and Treatment, 16 February 2006. Provides policy and assigns responsibility for preventing and treating hypothermia in combat trauma casualties.

- Memorandum, DA, Office of the Surgeon General, Subject: Management of Soldiers with Tension Pneumothorax, 25 August 2006. Alerted commanders and leaders of the proper equipment and steps for managing a tension pneumothorax. It advised unit commanders in theater that their combat lifesavers and combat medics could receive refresher training from trained medical personnel as needed.
- Memorandum, DA, Office of the Surgeon General, Subject: Army Medical Department (AMEDD) Pre-Deployment Trauma Training, 18 December 2006. To ensure perishable medical skills are effectively taught and reinforced prior to combat zone deployment, commanders and leaders were provided with desired pre-deployment trauma training certification levels by specialty and available course dates.
- Memorandum, HQ U.S. Army Medical Command, Subject: Optimal Resuscitation of Severely Injured Soldiers, 3 January 2007. Alerted commanders and medical personnel of the profound survival benefit to casualties who received massive transfusions when the plasma to packed red blood cell ratio was 1:1 and provided the web address for the current CENTCOM Clinical Practice Guideline for Damage Control Resuscitation and Transfusion.
- The following Clinical Practice Guidelines were developed and posted to the Joint Patient Tracking Application website:
  - Abdominal Blunt Trauma
  - Adult Severe Head Trauma
  - Burn Flow Sheet and Percentage Calculation Sheets
  - Damage Control Resuscitation for level IIb-III
  - Deep Vein Thrombosis (DVT)
  - Emergency Medical Technician (EMT) Thoracotomy
  - Factor VII
  - Fresh Whole Blood Administration Collection
  - Hypothermia
  - Irrigation of War Wounds
  - Pelvic Fracture
  - Transport – Transfer
  - Trauma Airway Management
  - Urologic Trauma
  - Vascular Injury

There are some efforts that do not clearly fall within the program management category taxonomy structure. The following have been classified as nonmedical efforts.

Nonmedical

- Blast Injury Testing Conference: To establish coordination among the researchers and user groups to cost effectively accommodate the urgent and overwhelming need for human vulnerability research.
  - *Status:* Ongoing. The first identified gap, the absence of adequate blast injury epidemiological data is currently being addressed.
  - *End Users:* Next Generation Body Armor/Warfighter Battle Damage Assessment programs.
- IED Armor Development—Add-on IED armor kit for Abrams Tank:
  - *Status:* Completed. Scheduled for production/fielding in FY07

  - *End User:* PM Abrams
- IED Armor Development—Add-on IED armor kit for Bradley Fighting Vehicle:
  - *Status:* Design complete, proposed production and fielding in FY07
  - *End User:* PM Bradley
- IED Armor Development—Add-on IED armor kit for Stryker Vehicle
  - *Status:* Design complete, no proposed fielding date
  - *End User:* PM Stryker
- IED Crew Seating: Mine/IED-resistant crew seating for Abrams Tank
  - *Status:* Design complete, production and fielding in FY07
  - *End User:* PM Abrams
- IED Crew Seating: Mine/IED-resistant crew seating for Bradley Fighting Vehicle
  - *Status:* In R&D, proposed production and fielding in FY07
  - *End User:* PM Bradley
- IED Crew Seating: Mine/IED-resistant crew seating for Stryker Vehicle
  - *Status:* Continuing. In R&D
  - *End User:* PM Stryker
- Next Generation Body Armor Program to Prototype Capability of Applying Epidemiological Data to Design Decisions
  - *Status:* Continuing. NGBA has already transitioned into the Warfighter BDA program. This work will also be used to evaluate the effectiveness of USMC PPE and the effectiveness of light tactical vehicle armor in support of development of the next Joint Light Tactical Vehicle.
  - *End Users:* U.S. Marine Corps Soldier System Command, U.S. Army Program Executive Office Soldier, and USAISR
- Interceptor Body Armor (IBA)/Cupola Protective Ensemble (CPE) Test—Validate Performance of CPE
  - *Status:* Completed
  - *End Users:* IBA program and CPE program
- CPE Thermal Viewer Test—Validate safety confirmation
  - *Status:* Completed
  - *End User:* CPE program

APPENDIX – ACRONYMS

ACH	Active Combat Helmet
ALARACT	All Army Activities
AO	Area of Operations
ARI	Aerodyne Research, Inc.
BABT	Behind Armor Blunt Trauma
BOP	Blast Overpressure
CBE	Chemical, Biological, Explosive
CCATT-DI	Critical Care Air Transport Nurse Deployability Index
CeMBR	Center for Military Biomaterials Research
CRF	Christopher Reeve Foundation
CS	Compartment Syndrome
CTR	Combat Trauma Registry
DA	Department of the Army
DoD	Department of Defense
DoDD	Department of Defense Directive
DoD EA	Department of Defense Executive Agent
DRDC	Defence R&D Canada
DSTL	Defence Science and Technology Laboratory
DTRA	Defense Threat Reduction Agency
DVBIC	Defense and Veterans Brain Injury Center
ECS	Engineering & Computer Simulations
EMG	Electromyographic
FDA	U.S. Food and Drug Administration
HIFU	High Intensity Focused Ultrasound
HMJF	Henry M. Jackson Foundation
HO	Heterotopic Ossification
ICP	Intracranial Pressure
IEA	Information Exchange Agreement
IED	Improvised Explosive Device
IND	Investigational New Drug
IV	Intravenous
JIEDDO	Joint Improvised Explosive Device Defeat Organization
JSF	Joint Strike Fighter
JTAPIC	Joint Trauma Analysis and Prevention of Injury in Combat
MACE	Military Acute Concussion Evaluation
MHS	Military Health System
MICE	Miniature Internal Combustion Engine
MNC-I	Multi National Corps, Iraq
mTBI	Mild Traumatic Brain Injury
NACTN	North American Clinical Trials Network
NE	Novel Explosives
NHLBI	National Heart, Lung and Blood Institute
NHTSA	National Highway Traffic Safety Administration
NGBA	Next Generation Body Armor
NGBS	Next Generation Bomb Suit
NHP	Nonhuman Primate
NHRC	Naval Health Research Center
NIH	National Institutes of Health
NME	New Molecular Entity

NVWG	National Veterans Wheelchair Games
NVWSC	National Veterans Winter Sports Clinic
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
PA	Project Announcement
PI	Principal Investigator
PPE	Personal Protective Equipment
PTSD	Post-traumatic Stress Disorder
QR	Quick Relief
RCT	Randomized Controlled Trial
RDECOM	U.S. Army Research, Development, and Engineering Command
SBIR	Small Business Innovation Research
SCI	Spinal Cord Injury
SWM	Surface Wound Mapping
TBI	Traumatic Brain Injury
TCCC	Tactical Combat Casualty Care
TGAS	Toxic Gas Analysis Software
TSWG	Technical Support Working Group
TTP	Tactics, Techniques, and Procedure
TTCP	The Technical Cooperation Program
USAARL	U.S. Army Aeromedical Research Laboratory
USAF	U.S. Air Force
USAISR	U.S. Army Institute of Surgical Research
USAMRMC	U.S. Army Medical Research and Materiel Command
UTC	Unit Type Code
UV	Ultraviolet
VA	Department of Veterans Affairs
VISIN	Veterans Integrated Service Network
WPSM	Warfighter Physiological Status Monitor
WRAMC	Walter Reed Army Medical Center